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INSTITUTION OF MECHANICAL ENGINEERS

SUMMER MEETING IN HOLLAND

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INTRODUCTION

NEXT week the Institution of Mechanical Engineers will be holding its Summer Meeting in Holland. It is the first time that Institution has taken its members abroad since 1931, when a visit was made to Canada. Not since 1922, when a meeting was held in Paris, has the Institution taken its members to the Continent. It is obviously a special occasion. In honour of it we have printed this special Supplement.

After so long an interval we doubt whether a better choice of a country in which to hold a meeting abroad could have been made by the President and Council of the Institution than Holland. There for example, the language difficulty is less insistent than anywhere else in Europe. Almost everyone speaks English. Nor are the customs of the country, though attractively different from ours, altogether foreign. For the mechanical engineer there is much to see. He will be all the more interested to see it because the Dutch are Britain's competitors in many world markets. In the pages that follow we describe a number of the works and organisations which members will visit, and we have attempted to pick out for mention in each place particular operations or particular products which we think members will like to study and which will interest others unfortunately unable to attend the meeting.

But the interest of Holland goes far beyond its factories and works. However much a mechanical engineer may have specialised in that field of engineering he is bound increasingly to realise as he travels in Holland how low-lying is much of the land, how much the Dutch people depend upon engineers to protect them from incursions of the sea. The level of the waters in major canals and in the rivers stands in many places far above the level of the land. Nor is it only the sea which can flood the land. The Haarlemmermeer, a great sheet of inland water south of Amsterdam, was originally drained by three remarkable Cornish engines built in the forties of last century. The final pages of this Supplement describe them. It is now kept dry only by continuous pumping. So, too, are many other areas. The disaster suffered by Holland in February of last year, when, as also upon England's Eastern coasts, the sea overtopped and breached the dykes, was serious enough. But only by visiting Holland, only by realising how much of the country has been reclaimed from the sea or from mere and marsh, can it be appreciated how vast in magnitude that disaster might have become if prompt action had not been taken to repair certain of the more critical breaches. We include in this Supplement therefore some account of that work. We also include, since some of the members will be visiting a Zuider Zee polder, a few particulars of the great Zuider Zee dyke, undoubtedly one of the wonders of the modern world. That dyke has made the Zuider Zee a fresh-water lake instead of an arm of the sea and has made possible the draining of polders such as the one members will visit.

Reference is also made to the road works being carried out by Dutch engineers. Little enough road work is being done in England. But in Holland, as members will no doubt see during their travels, much work is going on. In particular, a fine new double-track road is being constructed between Amsterdam and Utrecht. The railways, when the Germans left, were about 80 per cent out of action for want of rails, of rolling stock, of signals, and of almost everything else, and many bridges were down. They have been reinstated. Structural engineers and those interested in architecture should, if they can find the time, see how vigorously and effectively the centre of Rotterdam, blasted flat by German bombs almost before the Dutch knew they were at war, is being rebuilt.

Certainly there is no lack of interest for engineers in Holland. There is much else we have not mentioned. There are the great ports of Rotterdam and Amsterdam ; shipbuilding and ship-repairing yards ; the great Nord Zee ship canal connecting Amsterdam with the sea ; the great barge canal, connecting the same city with the Rhine ; some 25 per cent of Holland's oil requirements are met from its own oilfields near the German border ; there is the great new steel works at Ijmuiden which some of the members will visit.

But how will the ladies fare ? We have no doubt that they will enjoy themselves. The Hague is a fine city with fine shops and fine buildings. It is the seat of the Government. Amsterdam, the commercial capital, with its multiplicity of canals and its many old buildings, is a delightful city to visit. There is the flower market at Aalsmeer, the beauties of Delft, and everywhere the charm of Dutch villages and the kindliness and helpfulness of Dutch people. Maybe the country is a bit flat. The Dutch refer to the line of sand dunes that help to hold out the sea along Holland's Western coasts as " the Dutch Alps " ! But there are canals and waterways everywhere to relieve the scene, fields of flowers, farms, cattle. In many places, even at Scheveningen itself, the national costume is worn by some of the inhabitants. The charm of the country is not immediately apparent. It grows upon the observer unawares ; so that, like good wine, even if it is not fully appreciated at first, it is savoured afterwards in remembrance. Members who visit Holland will, we are sure, want to go back again. And why should they not ? After all, Amsterdam is closer to London than Edinburgh or Glasgow and about as easily reached. It would be simple to make a more extended visit than a Summer Meeting allows.

PART I—WORKS VISITS

THE members of the Institution of Mechanical Engineers will be officially welcomed to the Netherlands by Mr. F. M. A. Schokking, the Burgomaster of The Hague, and Dr. J. A. Ringers, the president of the Koninklijk Instituut van Ingenieurs, on the morning of Tuesday, June 15th. In the course of the subsequent general meeting Ir. F. Q. den Hollander, the president of the Netherlands Railways, will present an address on "The Industrial Netherlands." A series of visits have been arranged for the afternoon and the engineering establishments to which members have been invited include the Wilton-Fijenoord shipyards, and Allen and Co.

WILTON-FIJENOORD SHIPYARD

Arrangements have been made for members who visit the shipyard of Wilton-Fijenoord N.V. to make a brief tour of the workshops and to see some of the vessels at present under construction, overhaul and repair.

This well-known firm was formed in 1929 by the merger of two firms from Rotterdam—Wiltons Engineering and Slipway Company, which was founded in 1854 by Bartel Wilton; and the Fijenoord Shipbuilding and Engineering Company, which originated from the Netherlands Steamship Company, established in 1823 by Gerhard Moritz Roentgen. The present works at Schiedam were opened in 1918 by the Wilton concern, which acquired a site of some 170 acres in extent in anticipation of future extensions. The Rotterdam works of the Fijenoord Company were transferred to more up-to-date premises at Schiedam in 1933.

The shipyard is fully equipped for building all forms of merchant vessels, tankers, liners, cruisers, destroyers, submarines, &c., and during their tour the visitors will see amongst other vessels under construction two tankers, a destroyer, minesweepers and a whale factory ship.

The tidal docks owned by the firm cover an area of about 35 acres, and it has a large double graving dock, which can be seen in one of the photographs we reproduce. This double dock is a reinforced concrete structure, 650ft long and 280ft wide, and in it the construction of two vessels can proceed simultaneously. In addition to the cranes at each side, the full length of the dock is now served by a new 40-ton cantilever crane, which travels on a centrally disposed track between the two construction berths. A large new graving dock is at present under construction on the opposite side of a tidal basin which separates the main shipbuilding section of the works from the engine division. When completed this new graving dock will be some 103ft wide by 692ft long.

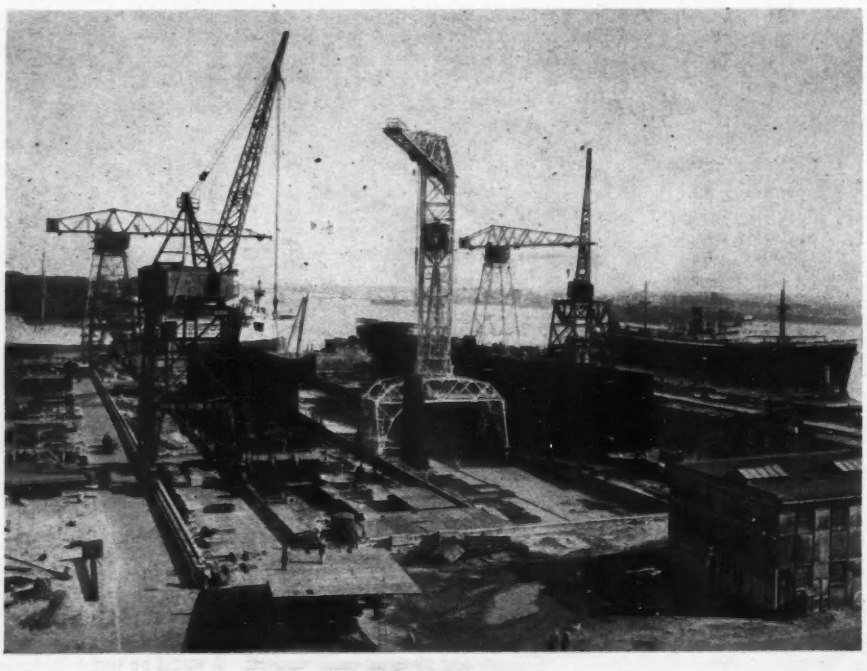


Fig. 1—Double graving dock at Schiedam

Five floating docks which serve the yard have capacities ranging from 4500 tons upwards, and they include the largest dock of its kind on the Continent. This dock is 695ft long by 168ft wide and it is capable of lifting ships of up to 46,000 tons.

The largest of the shipbuilding berths is some 540ft long and is designed for lengthening up to 800ft. The hull of a whale factory ship is now in an advanced state of construction on this berth and, when completed, this vessel will have a deadweight of some 26,400 tons. Although the visitors will not have time to board this interesting ship, they will be able to obtain a good impression of its lines and size as they pass the berth in the course of their tour.

Fig. 2—Main platers' shop at Wilton Shipyard

Of the shops to be visited, one of the more interesting from the point of size and layout is the main platers' shop, a corner of which can be seen in the accompanying illustration. This shop, which has a floor area of just under 230,000 square feet, is arranged in seven main bays. It is equipped with a particularly wide range of modern plate and section forming, cutting and welding plant, including plate presses of up to 1200 tons capacity. Large unobstructed floor areas served by fourteen overhead travelling cranes facilitate the marking out and laying off of plates, and the fabrication and manipulation of bulky and heavy sections on the presses, rolls, profile cutting machines, &c.

In keeping with modern practice, many parts of ships are now prefabricated at Schiedam, and for this special class of work a new shop was recently built close to the main platers' shop, from which it receives its supplies of preformed plates and sections. This new prefabricating shop, which has a floor area of some 3350 square feet, is served by a 40-ton overhead travelling crane and is fully equipped with electric welding plant. Its floor, as can be seen in the illustration (Fig. 3), is set out with a system of steel levelling rails on which parts can be laid out accurately and clamped together for welding. The exceptional height of the crane rails—

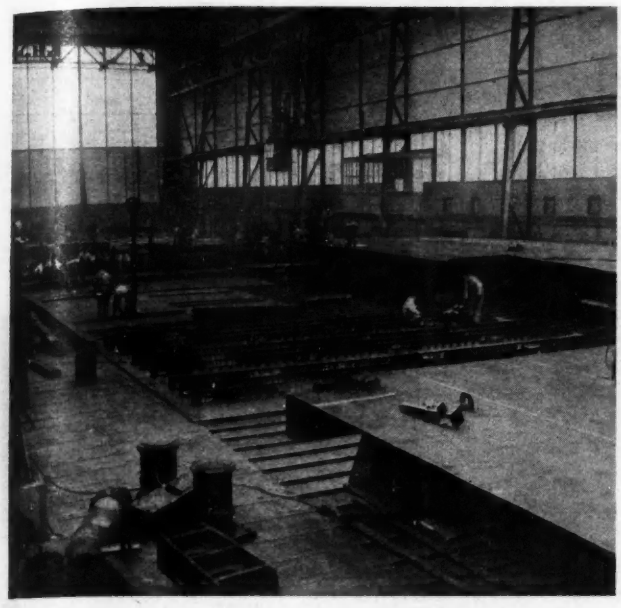


Fig. 3—Prefabrication shop for ship members

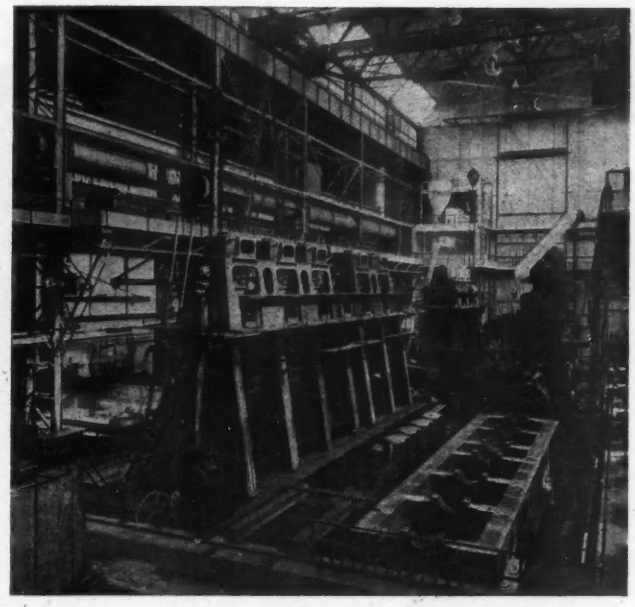


Fig. 4—Engines on test beds at Wilton Engine Works

65ft—enables bulky as well as heavy units to be handled. Particularly large doors have been provided at one end of the shop so that the trailers used to transport the prefabricated units to the ships under construction can be driven right into the building for loading. Most of the building berths in the yard are served by cranes capable of handling prefabricated units weighing up to 40 tons.

The main engine works is equipped with plant for building large M.A.N. and Doxford marine oil engines of up to 10,000 h.p. and Pametrada steam turbines, the smaller sizes of diesel engines up to 1000 h.p. being built in a separate shop. The size of the work which the plant is capable of handling can be appreciated from our view of the test beds (Fig. 4). Following general practice, the heavy machine tools are arranged along the main bay and the lighter components are made on machine lines in side bays. The two large test beds at one end of the shop have been built side by side in a pit below the floor level in order to give the required height for handling parts for the larger sizes of engines. Either of these beds is of sufficient size to allow the erection and testing of the largest oil engines, or two or three smaller engines. Steam turbines and condensers are built and tested in a bay at the side of the oil engine test beds. Heavy forgings, such as those required for crankshafts, stern frames, propeller shafts, &c., are supplied to this works from a forge at the old Wilton works, which is still in production at Rotterdam.

Allan and Co.

The members who visit the works of Allan and Co. will have an opportunity to see in course of construction some of the diesel-electric railcars of modern design now in service on the Netherlands Railways. This works, which has been closely associated with the development of railway rolling stock and tramcars for many years, owes its origin to a Scotsman named Allan who, early in the last century, started a textile and furniture importing business in Rotterdam. In 1839 Mr. Allan extended his interests by starting a cabinet-making business in which he was joined in 1855 by a Mr. Hoefnagles. The two partners were progressive and were amongst the first manufacturers in the country to introduce steam-engine-driven machinery into their factory. About 1900, when Mr. A. W. van Berkel, the father of the present managing director, joined the firm, the construction of railway coaches and tramcars was started. Although it built wooden coaches on steel frames for many years the firm was prompt to adopt, first, the all-steel riveted form of construction, and later, in 1930, the all-welded method of construction. It now builds rigid self-supporting frameless coach bodies mounted directly on bogies for both railcars and tramcars, as well as diesel-electric locomotives.

There is at present passing through the shops of this company a very large order for diesel-electric railcars for the Netherlands Railways, and visitors will see the production methods, tooling and equipment developed for this work. Under the system adopted for this contract all the component parts for the coaches are cut and formed to very close tolerances in the main plate shops and sent in sets to the main erection department shown in Fig. 5.

The floor of this shop has been laid out with large assembly jigs, in which the preformed beams, panels, plates and sections, &c., of the various parts for a coach body are clamped together and welded. The jigs used are not only designed to provide a means of holding the parts for welding, but also to provide a check on their accuracy so that only components of the correct size and shape can be used. By using these checking fixtures for welding together the main sub-assemblies, when they are mounted in final coach assembly jigs (to be seen on each side at the far end of the shop in Fig. 5), little or no rectification is required and consistent production is ensured. All welding of the major sub-assemblies is carried out down-hand, and one of the large manipulator rigs installed for this purpose

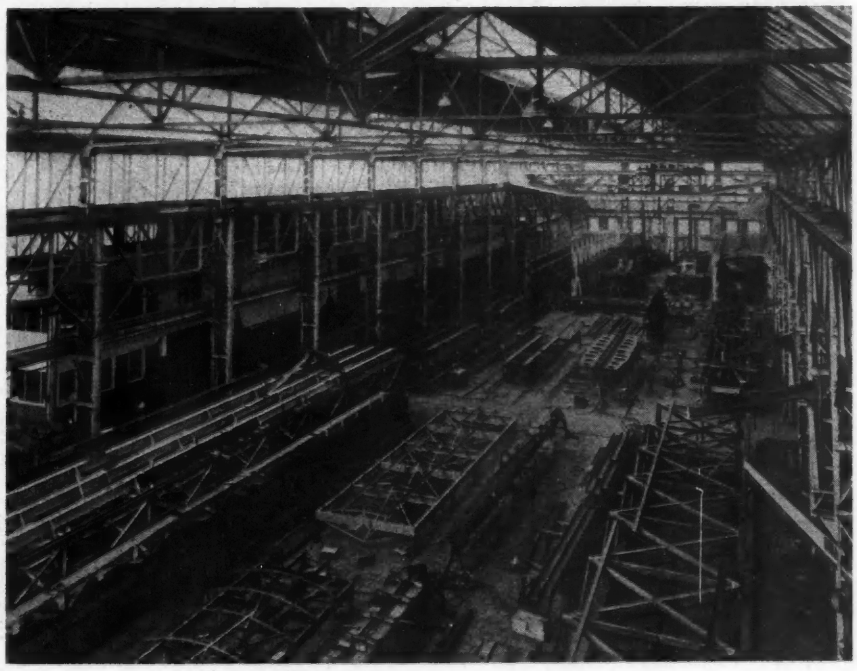


Fig. 5—Main railway vehicle assembly shop at Allan and Co.

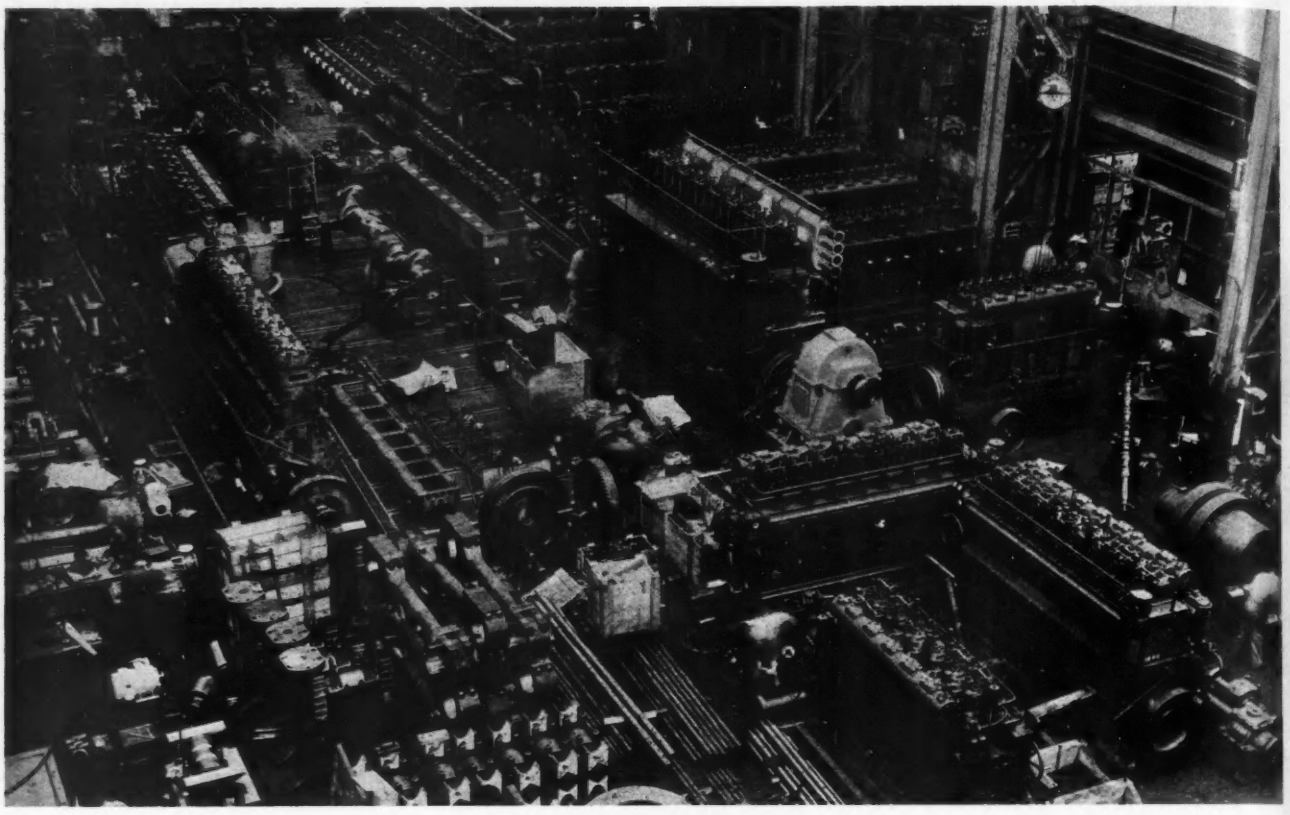


Fig. 6—Erection shop for large oil engines at Werkspoor Works

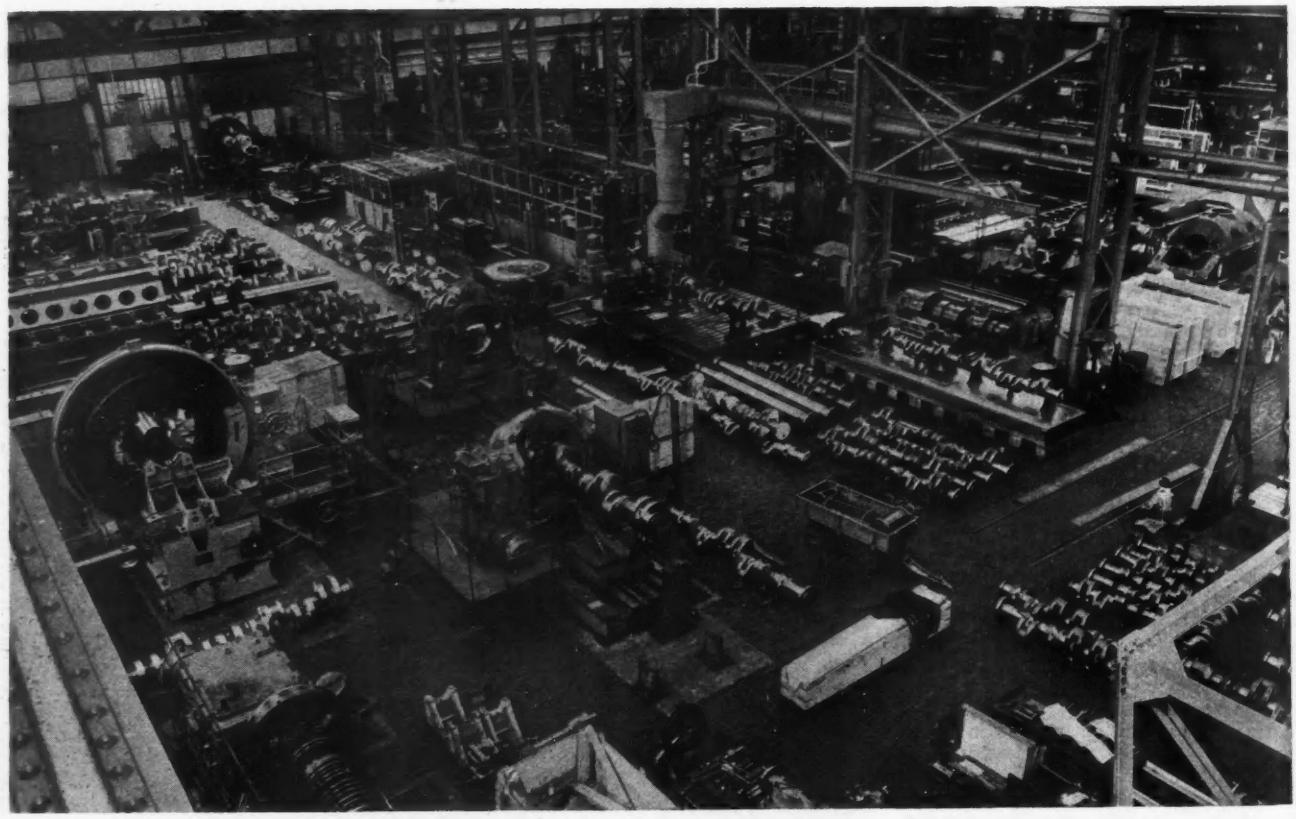


Fig. 7—Crankshaft machining bay of heavy machine shop

can be seen in the foreground of the illustration.

The bogies for the vehicles are welded assemblies of plates cut and formed to close tolerances in a similar way to the coach body parts. In connection with these bogies an interesting machine has been developed and built by the firm for final boring and facing of some fourteen bearing holes, which is carried out on the completed assembly to ensure alignment. This machine, to be seen in the photograph reproduced below, consists

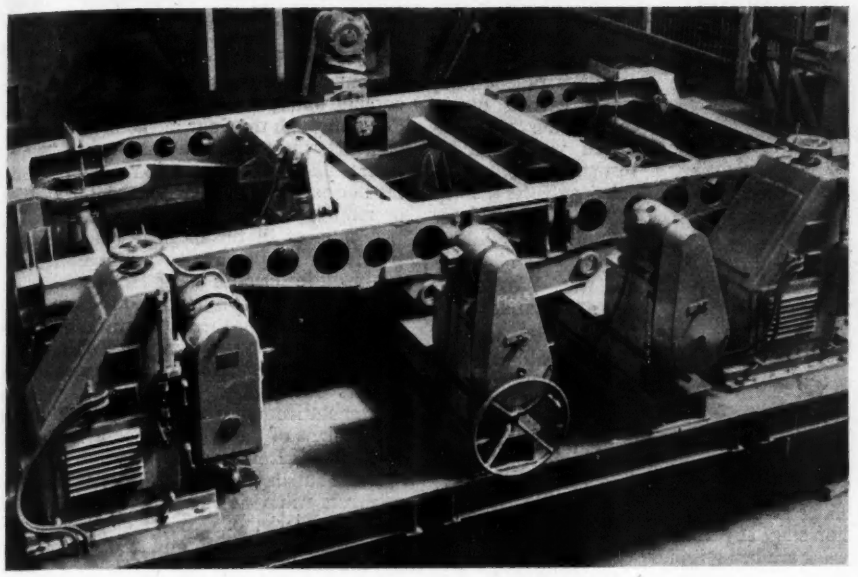


Fig. 8—Jig for boring holes in bogie frames

of a rigid platform plate fitted with supporting and locating pedestals for the bogie frame.

Eight motor-driven drilling units mounted on slides bolted to the platform bore the holes out in true alignment and to the required size in two settings of the bogie frame. The total time required for setting and drilling a frame on this machine is about four hours. It should be pointed out here that the bogie drilling machine, like many of the assembly jigs, is so designed that the main elements can be repositioned and aligned to accommodate similar components for vehicles of different sizes when the present contract is completed.

The coach bodies and bogie frames are cleaned after assembly in a large shot blasting chamber before they are painted. The bodies are then mounted on their bogies and the underfloor diesel engine generator sets installed. Interior finishing and furnishing of the coaches is done in a department of the factory which has for many years specialised in this class of work, both for the vehicles built by the firm and for other contractors.

In addition to making railway rolling stock tramcars and bus bodies, the firm has a large cabinet-making department which specialises in the design and manufacture of ship's furnishings and panelling, and the visitors will see here many interesting and attractive examples of its work.

During recent years two new developments have been introduced by the firm, one of which is the manufacture of hydraulic press brakes and guillotine shears of all-steel fabricated construction. Some of these machines are to be seen in operation in the plate shops. It is also now making sublimation drying installations and auxiliary apparatus for blood storage purposes.

A number of visits, each of which will occupy the whole day, have been arranged for Wednesday, June 16th, and they include one in the afternoon to the Amsterdam works of Werkspoor N.V., following a morning tour of the K.L.M. repair shops at Schiphol Airport.

Werkspoor N.V.

The firm of Werkspoor N.V. was founded in 1827 by Paul van Vlissingen, and it is one of the oldest engineering establishments in the Netherlands. These works are of particular historical interest as the original workshops were housed in the buildings of the former East India Company at Oostenburg. An imposing works hall in which members will be received is actually on the site of the original East India Company's premises, and a spacious modern theatre for employees has been built adjoining this hall. The works buildings cover an area of some 34 acres and are built on a site which is known locally as " the islands " as there are still sections of canal between some of the workshops. Reconstruction, extension and modernisation of the older buildings is continually in progress and there are now many large, well-equipped, modern shops engaged in production of all kinds.

The firm has another large factory at Utrecht engaged in the manufacture of railway rolling stock and bridges, and the erection of oil refineries and associated plants. The Amsterdam works is particularly concerned with the production of a very wide range of industrial and marine oil engines, steam turbines, boilers and a variety of equipment for all branches of engineering ranging from pumps and compressors to complete sugar mills and chemical plant installations.

When it started the firm was mainly engaged in the manufacture and repair of reciprocating marine steam engines, and with the passage of the years its products were extended to include land installations, boilers, &c. Early in the twentieth century the company became interested in the diesel engine and built its first engine of this kind in 1902. From then onwards Werkspoor has been closely associated with the development of the diesel engine, and it is of interest to note that it was responsible for the construction of the first direct-reversing, four-stroke, marine diesel engine for ocean-going ships which was supplied in 1910 for the vessel " Vulcanus." It now builds a wide range of high, medium and low-speed oil engines for all applications.

It will be appreciated that in the few hours they will be at this works the members of the Institution will be able to obtain only a slight impression of the vast amount of work in progress. But it will be obvious to all that the work carried out here, despite its variety and the complexity of the organisation, is to the highest standards. Many interesting manufacturing methods and machines will be seen in the departments to be included in the tour of inspection.

The tour of the works will begin at a group of shops at one end of the factory where all of the light and medium machining capacity is concentrated. These shops are engaged largely in batch production, and from them components are supplied to assembly departments in all parts of the works. The visitors will then be taken through the various shops engaged in engine building, turbine erection, boiler making, forging, sugar, chemical and other industrial plant manufacture, plate work, pipe bending &c. Two of the shops which will impress most visitors are an erection and testing department for large oil engines and turbines, and a heavy machine shop. Some idea of the size and test bed capacity of the testing department can be obtained from one of the photographs reproduced on the page opposite, where a number of medium-sized oil engines can be seen in various stages of erection. The equipment installed in this shop enables oil engines up to 10,000 h.p. and steam turbines up to 60,000 h.p. for ship propulsion and turbo-generator sets of up to 120,000kW to be erected and tested on the beds.

The machine shop in which all the large and heavy components for the engines and other equipment are made is a spacious single-storey building with good headroom and ample lifting capacity to cover the whole floor area and serve the individual machines. One bay of this shop is equipped with up-to-date machine tools for the manufacture of large crankshafts, which are forged in another department of the works. The equipment of this bay and the amount of work this section handles can be appreciated from the accompanying illustration (Fig. 7) showing one corner of the bay, and the large planing machines used for engine beds, &c., can be seen in the bay in the background.

The small and medium sizes of oil engines are erected and tested in individual shops, and one of the more recent departments laid down was that for the assembly and test of the firm's " R.U.B." type high-speed diesel engines, which are made in large numbers. In this department the engines after assembly are transferred to an adjoining test building which is divided into a number of individual cubicles, each complete with its own range of testing equipment. Each engine is delivered to the entrance of its test cubicle on a truck and transferred to the test bed by means of an overhead hoist, the runway of which extends out over the roadway. Once the engine is bolted down on its bed as shown in Fig. 9, it is quickly connected to a dynamometer, the fuel and cooling water supply lines and the exhaust gas duct. All the necessary gauges and recorders are arranged on one side of the cubicle above an inspector's desk, where he can conveniently write his reports. The cubicles and their doors are well insulated to prevent transmission of any noise to adjacent buildings

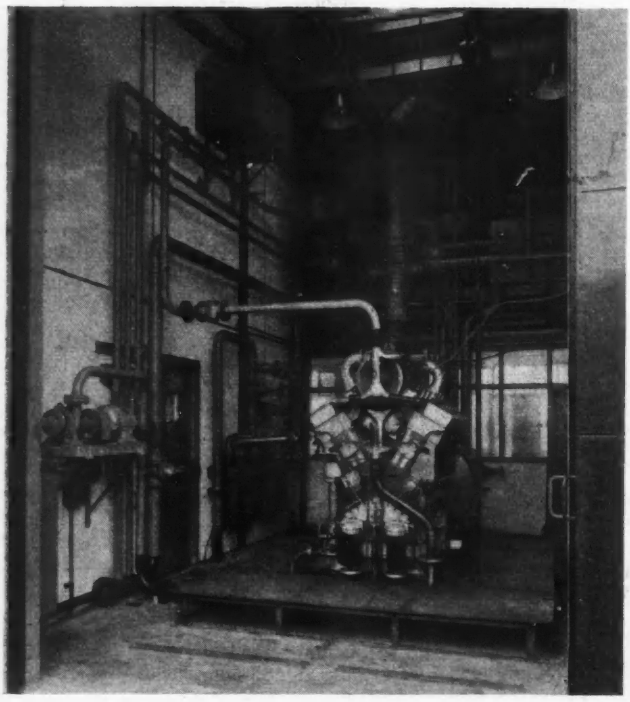


Fig. 9—Oil engine test cubicle

whilst the engines are undergoing tests.

Members who are interested in training will be impressed by the Werkspoor apprentices' workshop, which is virtually a complete, independent, well-equipped works within the main establishment. Boys leaving school first attend a continuation school situated in the works where initial teaching is given an engineering bias. On leaving this school the boys enter their own workshop where for about two years they are trained in production on modern equipment by skilled instructors, after which they complete their apprenticeship in the manufacturing departments.

Another group of visitors will travel by motor coach to Delft, where they will inspect the engineering workshops and laboratories of the Technological University.

The Technological University at Delft

The normal research and training facilities of the university are supplemented by its close association with laboratories of the Technisch Natuurwetenschappeijk Onderzoek, which have been laid down for the purpose of giving assistance and scientific support to Dutch industries.

One of the laboratories to be visited is the particularly well-equipped department for metal processing and workshop organisation research illustrated in Fig. 10. In this building some fifty-eight modern machine tools and ancillary equipment are used for research work in turning, milling, grinding, deep drawing and extrusion, time and motion study, &c. The metallurgical laboratory is shortly to be moved into a new building and its research work is at present mainly concerned with fatigue testing, investigating stainless steels, corrosion, &c. Its principal work is in the training of students, and each year some 700 students complete the three-year course, which includes mechanical testing, metallography and heat treatment.

A considerable amount of research work is carried out on internal combustion engines, and two laboratories—one for diesel and one for petrol engines—have been equipped for this purpose. The diesel laboratory building has a floor area of about 25,000 square feet, has installed in it various designs and makes of engines ranging from 10 b.h.p. to 250 b.h.p., complete with hydraulic brakes, &c. A small chemical laboratory used for tests on fuels and lubricants also serves a similarly well-equipped petrol engine laboratory.

In these internal combustion engine laboratories student training is carried out in conjunction with research work and investigations on particular subjects at the request of private manufacturers.

Railway Workshops at Tilburg

Another group of members will be taken by special train to the central workshops of the Netherlands Railways at Tilburg, which are mainly concerned with the repair, overhaul and maintenance of locomotives. These shops at Tilburg are in an interesting transition stage at present, as the Netherlands Railways are being rapidly converted from steam to electric traction, and within the next few years all its lines will be served by electric or diesel-electric locomotives or railcars. The workshops are at this stage engaged in the repair and maintenance of a steadily decreasing number of steam locomotives as well as diesel-electric and electric locomotives.

Amongst the shops to be visited during the tour of the works is one which has been laid out for the repair and overhaul of diesel engines and electrical equipment. The incoming engines are stripped down and all the parts cleaned at one end of the shop and laid out for inspection. The parts requiring repair or renewal are then removed and the remainder of the engine stored in stillages until replacements are provided or the reconditioned parts returned. The complete set of component parts is then transferred to a rebuilding area farther along the shop, where the engines are reassembled. Whilst an engine is being overhauled on one side of the main shop its electrical gear is overhauled and serviced at the same time on the opposite side of the shop.

Reconditioned engines are tested and adjusted in a new test house which was recently put into commission at the works. The test beds, which have been laid down in this building, are each suitable for testing engines up to 900 h.p. Here all the control and recording gear has been installed in a large corridor adjoining the test beds and insulated from them by soundproofed walls. From this corridor the testers can control the engines and keep them under constant observation through windows whilst working in comparative quiet. All the lines for fuel, cooling water, &c., to the engines are taken down through the floor of the beds to supply and metering tanks in a basement below, so that, whilst connections can readily be made, the floor area is left clear for the introduction or removal of engines.

A number of the original steam locomotive repair shops have been reorganised and equipped for electric and diesel-electric stock dismantling and overhaul, and in only one of the largest shops is there still a certain amount of steam locomotive work now carried out. Whilst they are walking round these shops the visitors will have a good opportunity to see representative types of the different makes and designs of the rolling stock in use on the Netherlands Railways.

On Thursday, June 17th, one group of members will visit Hengelo, where they will visit the works of Koninklijke Machinenfabriek Gebr. Stork and Co., Ltd., and G. Dikkers and Co., Ltd.

G. Dikkers and Co.

The firm of G. Dikkers and Co., N.V., which manufactures valves of all sizes for steam, water, air, chemicals, oil, &c., was established in 1879 and it now employs some 1700 hands in a group of shops covering an area of about 500,000 square feet.

The works is organised broadly in two divisions. One division is concerned principally with the actual manufacture of valves and fittings, and in the other a group of foundries produces steel, iron, non-ferrous, gravity die and precision castings for the firm's own valves and for other manufacturers.

In the valve production division the main machine shop, a corner of which can be

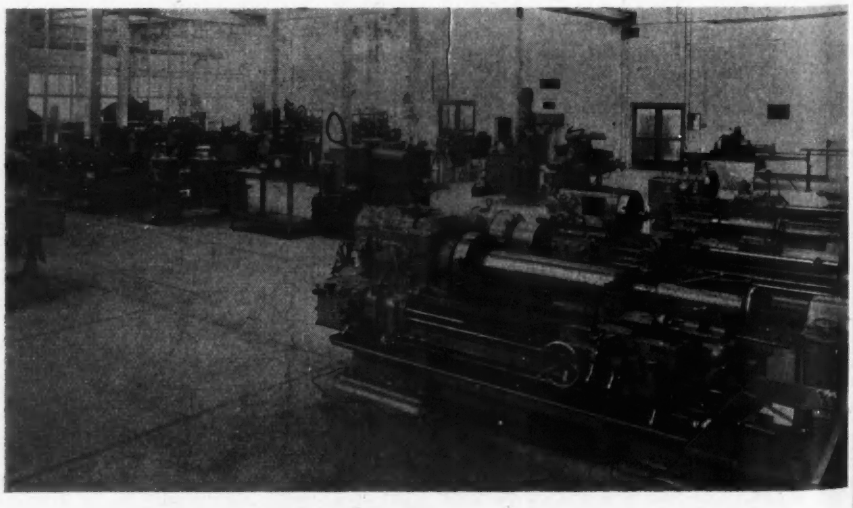


Fig. 10—Machine tool laboratory of engineering department at Delft University

seen in the illustration below, is laid out for the machining of components in batches. In it the machines are generally grouped for different types and sizes of valves, whilst separate lines of automatics provide components such as bolts, studs, spindles, &c., applicable to ranges of valves and required in large numbers. The varying demands of the valve market dictate the sizes of the batches in production, but, irrespective of the number of valves made, the same system of very close tolerances is observed to ensure a high degree of interchangeability of components between batches. The standard of accuracy maintained also serves to eliminate necessity for rectification fitting on the assembly lines. Many special valves are made in this shop, often in small numbers, and each machining section is organised to enable components for such valves to receive individual attention without unduly interrupting the normal run of production.

The close working tolerances maintained on the production machines is to a large extent made possible by the organisation of a tool stores and tool grinding and reconditioning section at one end of the shop. Under the system laid down a complete set of tools for a machine is issued from this stores with each batch of work. When the job is completed the set of tools is handed in to a special section of the stores, where it is checked by inspectors. If necessary the tools are then sent into the adjoining section for any sharpening, repairs or replacements to be made before the set is entered into stores stocks ready for reissue. This system ensures that no undue delays are involved when setting up a machine, and there is no need for improvised tooling on the part of machine setters. A further advantage in using this system of issuing sets of tools with the job is that the operations on each machine can be planned to use it to its fullest capacity.

The standard types of valves after assembly are tested in a shop equipped with supply lines for air, steam and hydraulic pressure testing to all the required limits. For certain types of valves and fittings made in large numbers, special test rigs have been installed down one side of this shop, as can be seen in the photograph reproduced in Fig. 12. On these rigs groups of valves can be quickly and easily coupled to a common manifold through which the testing fluid is supplied. Against the outer wall between the rigs there are special connections and fittings for testing special valves and those made in smaller numbers. Every valve made is tested in this shop and then examined for operation, finish, &c., before release to the packing and despatch department. All high pressure valve bodies undergo radiological examination after machining and heat treatment to ensure that they are free of flaws.

The ferrous foundry of this works is of particular interest as in it both steel and iron castings are made on the same floor, and in addition to two cupolas it is served by two converters and a high-frequency induction furnace for alloy steel castings. Steel castings are produced on Mondays, Wednesdays and Fridays, and iron castings on Tuesdays and Thursdays. Under this programme moulds for steel castings are made on Monday morning, and whilst they are being poured during the afternoon the preparation of moulds for iron is started. On Tuesday morning the iron castings are poured and during the afternoon steel moulds are made for pouring on Wednesday morning—and this rotation of mould preparation and pouring is followed for the remainder of the week.

It will be appreciated that with this rotation of iron and steel moulding a very close control has to be maintained to segregate the different sands apart. This is being done quite successfully and to give a better margin of sand control a new sand recovery and preparation plant is at present being installed. To control this plant a laboratory has been built adjoining the foundry for the special purpose of making continual checks on the outgoing material to the storage hoppers and machines in the foundry.

Most of the raw material used in the foundry is obtained from high-quality scrap, and a well-equipped works laboratory is responsible for testing all incoming scrap, and allocating it for holding in appropriate bins in a large stock yard. From this yard the batching of scrap for issue to the foundry is also made the direct responsibility of the laboratory to ensure that consistent quality is maintained in the castings produced.

The firm has also a large non-ferrous foundry, which specialises in copper and aluminium alloy castings, and a gravity die casting section. A research section associated with the production control laboratory is fully equipped for investigations into new material and foundry processes. In a separate non-destructive testing department high-grade castings intended for the automobile industry and naval applications are inspected for cracks and soundness of material.

STORK AND CO., LTD.

When the members visit the works of Koninklijke Machinefabriek Gebr. Stork and Co., Ltd., they will see a works which has grown from a small factory established by the late Charles Theodoor Stork in 1868 to an organisation employing some 5000 people and with shops covering an area of 32 acres. As with many such concerns started in the nineteenth century, the firm's first products were mainly reciprocating steam engines and boilers. In later years its interests widened—in 1883 production of equipment for the cane sugar industry was started, in 1905 steam turbines were added to the list of products, followed by water-tube boilers in 1908, centrifugal pumps in 1910, fans in 1915 and oil engines in 1930. Separate manufacturing establishments were set up after 1946 for the production of oil engines up to 1000 h.p. and small pumps, and the company has five subsidiary firms in other parts of the country for other engineering products.

One of the most impressive buildings at the Hengelo works is the main workshop, in which oil engines up to 10,000 h.p. and steam turbines up to 55,000kW are built. It will be recalled that in our issue of December 18th last we described and illustrated a new design of single-acting, two stroke, supercharged marine diesel engine of 8500 b.h.p. built in this shop.

The main workshop building itself is some 650ft long by 105ft wide and 68ft high. Balconies on each side are equipped with the light and medium machine tools producing parts for the engines and building subassemblies. Heavy machining is carried out in bays below the galleries and in the centre of the workshop, to be seen in one of the illustrations on the page opposite. At the far end of the shop the large diesel engines are tested on a bed 190ft long by 20ft wide. Immediately beyond the oil engine test beds at the end of the shop is a large gallery on which steam turbines are erected and tested. A photograph we reproduce of this gallery

Fig. 11—Main machine shop for valve components at Dikkers Works

Fig. 12—Valve test shop with multiple test rigs

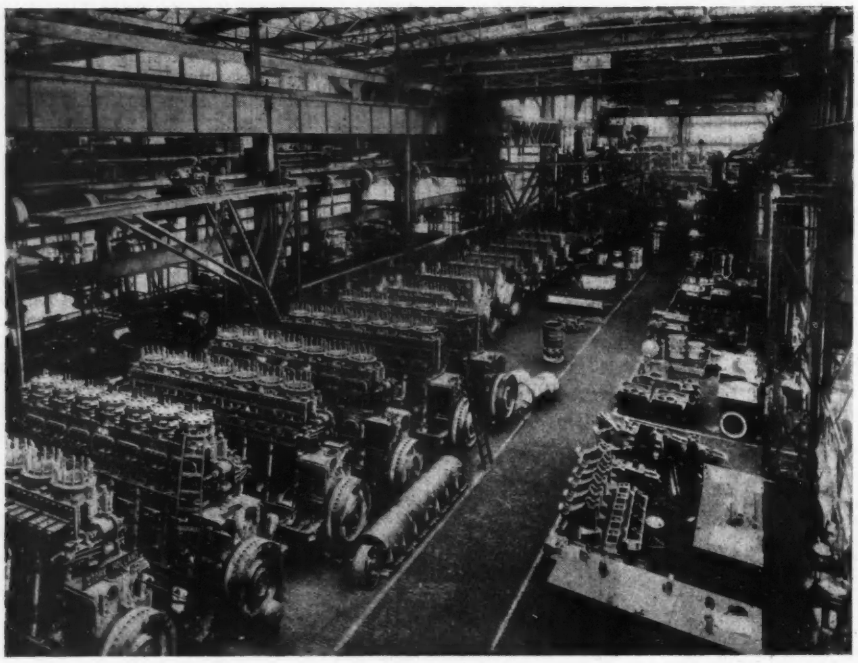


Fig. 13—Oil engines being assembled in the main shop at Stork Works

shows (Fig. 14) two turbines during erection—one for a Stork 20,000/30,000kW generating plant and the other for a Stork-Metropolitan-Vickers 50,000/55,000kW set. This turbine erecting and testing section is served by a condenser set and an overspeed test house situated on the level of the main floor immediately below the gallery.

This works has one of the largest iron foundries in Holland, equipped for casting meehanite iron, and its three furnaces have a smelting capacity of 8 tons per hour, whilst castings weighing up to 50 tons can be produced. This foundry will be inspected in the course of the tour by members of the Institution who will have an opportunity to see many interesting castings being made by the cement-sand process, both for the Stork products and for outside contracts. A point of interest here is a method used by the firm for building up large composite cores from units for assembly before being inserted into moulds for three, four, six and eight cylinder, medium-sized oil engines. For this purpose the core for each cylinder is made as an individual unit and then joined to the required number of similar units, as shown in the accompanying illustration (Fig. 15), to form a rigid assembly. Needless to say, particular care and accuracy have to be observed in making the single cores, but this is well repaid by the ease and speed with which the assembly can be inserted in the mould.

In connection with this cement-sand method of moulding the firm has introduced a sand reclamation process which considerably reduces the amount of dust and wear on equipment normally involved in this class of work. The moulds are knocked out on a 6in mesh grid floor at one end of the foundry and the large lumps of sand are first reduced by being forced down through this grid. A conveyor belt below floor level transfers the lumps to an inclined belt provided with a magnet pulley for removal of tramp iron. This second belt elevates and deposits the lumps between a set of crushing rolls where the size is reduced to a maximum of about 2in cube. The reduced lumps fall into the boot of a bucket elevator which carries them to a storage bunker, and a vibrating chute at the base of this bunker feeds the material at a controlled rate into a ball mill where water is added. From this mill a continuous stream of water-borne crushed sand pours into a settling tank where the heavy grains of sand sink to the bottom and the fine dust remains in suspension. A scraper chain draws the washed sand from the floor of the tank and deposits it upon a system of conveyor belts which transfer it to adjacent stock piles ready for re-use. The flow of water from the settling tank carries the unusable fines to a second settling pit, whence the water is recirculated and the fines in the form of mud are removed periodically.

Fig. 15—Placing composite core in mould

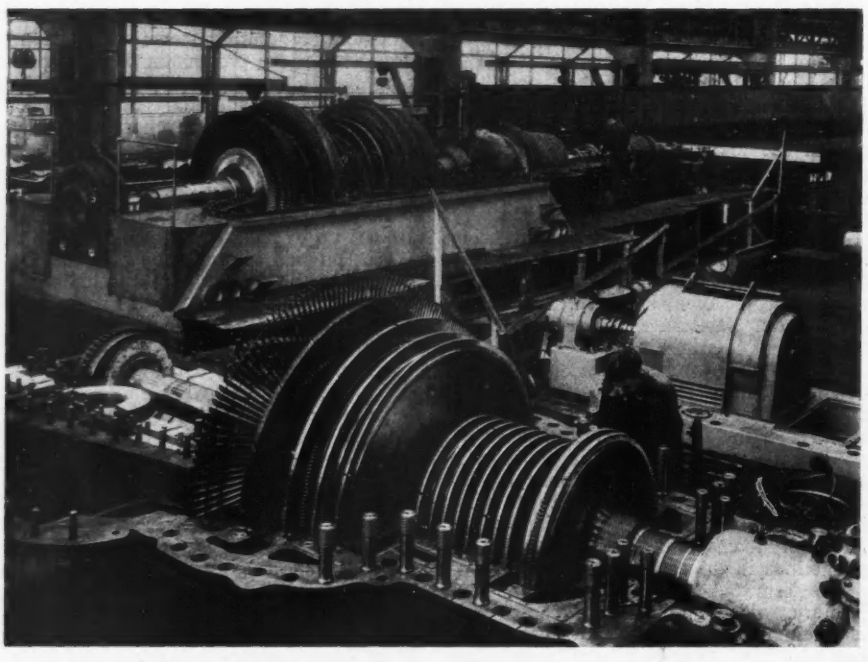


Fig. 14—Steam turbine erection floor

In addition to the normal routine laboratory control which is exercised in process working throughout the works this firm also carries out an appreciable amount of research in connection with equipment, raw materials, new alloys, &c. Facilities for this work of research were considerably extended and improved last year by the opening of a large new materials testing laboratory fully equipped for all classes of investigations into the materials and processes associated with the firm's products. Other laboratories engaged on development research in connection with the variety of plant made are equipped for the investigation of thermal, hydraulic and aerodynamic problems.

An interesting part of the organisation is the extensive use made of non-destructive testing methods and for this work there is a special department equipped with magnetic, fluorescent, X-ray and ultrasonic apparatus. Visitors will see a large protected bay specially built for X-ray examination of big components, which is equipped with a 250kV

"Raymax" set. This bay is served by rail tracks linking it with the works system so that large and heavy components can be brought in on bogies and examined without need for intermediate handling. The X-ray head is mounted on universal joints at the foot of a light tubular structure which can be traversed on its carriage along a bridge running across the full width of the bay. The bridge can be moved to any required position along the bay and, by its means of suspension, the X-ray head can be quickly and easily manœuvred to any required point in relation to large components. The control panel of the installation is conveniently situated in a cell built into the protective wall of the bay.

In connection with its well-organised apprentices workshop the firm maintains an initial training school for boys who leave the national primary schools at the age of thirteen years. These boys for one year attend the initial training school, where, in addition to theoretical work, they are encouraged to develop any natural handicraft tendencies by creative modelling in clay, simple woodwork, &c. After a year the boys start general work in a large well-equipped craftsmanship training shop. After two years here they graduate into the works production shops to complete their training by one further year's service.

Another party of members will travel by train to Eindhoven, where it will split up into two groups ; one group will spend the day at the Van Doorne's automobile factory and the other group at the works of Philips Electrical Industries, Ltd.

Van Doorne's Automobielfabriek N.V.

The firm of Van Doorne's Automobielfabriek N.V. has two factories in Eindhoven, and members of the Institution have been invited to visit the large new workshops, which were opened on the outskirts of the town in 1950. These buildings at present cover an area of some 15 acres, and they are not only impressive for their size and layout, but also for the way in which modern methods and equipment are being used to give a high standard of production combined with excellent working conditions for the employees.

This firm was started in a very small way in 1928 by Mr. H. J. Van Doorne and, following the development of a successful design of lightweight semi-trailer for road transport purposes, its growth was very rapid. These semi-trailers have a light rigid chassis of all-welded construction with a box-form central main girder of pressed steel plate to which the cross members are welded. They have automatic coupling devices for attachment to the tractor, and their front support wheels are automatically retracted by hydraulic mechanism when the tractor is coupled to the trailer.

The range of the firm's products steadily extended, particularly after the late war, and now includes semi-trailers, trailers, railway containers, lorries, motor coaches, and special military vehicles. A majority of the trailer work is now concentrated at the older factory in Eindhoven, whilst the other vehicles are made in the new works, where some 1500 hands are now employed.

Designs for the new factory were prepared during the war years, and it is interesting to note how the large unobstructed floor areas in the two main production buildings were planned to permit easy rearrangement of equipment to comply with production changes. The walls and roofs of the buildings are extensively glazed to give the best possible natural lighting in all parts, and glass-panelled internal partitioning only is used where necessary to isolate certain of the sections, such as those engaged in toolmaking, inspection, &c.

Fig. 17—Inspection station at end of vehicle assembly lines

When the system of line production of vehicles now being followed was planned it was appreciated that there would be a shortage of suitable skilled personnel for the class of work, and for this and other economic reasons it was decided to introduce the manufacture of commercial motor vehicles in four stages. In the first stage—now in full operation—chassis frames and certain ancillary equipment is being made. Under the second stage—now in process of introduction—front and rear axle assemblies will be manufactured. In two subsequent stages it is expected to introduce the manufacture of gearboxes and engines. It will thus be seen that the factory is at present making all the chassis members and assembling the complete commercial vehicles from components supplied by other manufacturers. With regard to the large numbers of military vehicles now being produced by the firm, all of the parts with the exception of the engines and gears are made in the works.

The production lines are laid down in two main buildings, which are fronted by a two-storey office block, canteen, &c., and ancillary buildings are arranged for servicing, maintenance and overhaul work. All raw materials are delivered by canal or rail to a large stores adjoining stockyards at the end of the building mainly concerned with the manufacture of chassis members. Sheets and plates are delivered from this stores straight on to the press lines, where the component parts of the chassis and bodies are cut and formed. These parts are assembled into units, which are fed on to welding lines at appropriate stages for assembly into complete chassis, drivers' cabs, bodies, &c. The assemblies are then transferred to a large stores area in the adjoining main building.

At the end of the chassis parts store area and extending the full length of the shop is the rust-proofing, painting and finishing line illustrated on this page. Parts from the stores are suspended on hooks of an overhead conveyor line which serves the whole of this section of the works. After cleaning and rust-proofing the assemblies are carried through large paint spraying booths and drying ovens, and are removed from the

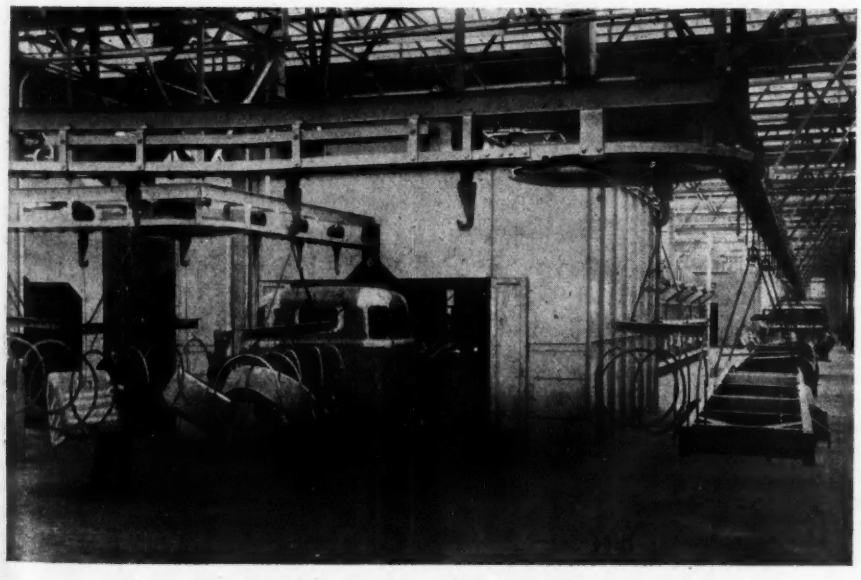


Fig. 16—Chassis and body component cleaning, proofing and painting line

return side of the conveyor at the head of the main vehicle assembly line. Here the chassis frames are placed on carriers coupled to a slowly moving conveyor.

At the side of the main assembly line are sub-assembly areas responsible for the preparation and building up of units such as axles, transmissions, steering, engines, &c. These sub-assembly areas are supplied with components from a large, well-equipped machine shop and with bought-out units such as engines, transmissions and axles from conveniently situated stores. All purchased components undergo thorough inspection before issue from their stores, and test beds have been installed for testing a large percentage of the engines before use. As a chassis frame progresses from station to station on the assembly line various units are fitted until at the end the completed vehicle is ready for final inspection in the section shown in Fig. 17.

From this section the vehicles are driven out of the building on to a test road adjoining the factory before being taken to the delivery section.

A point of interest members will note in connection with this main assembly line is that no less than three different types of vehicle are being built on it at the same time —two forms of military truck and chassis for commercial trucks or tractors. This naturally calls for careful planning of the positions of the sub-assembly areas and the rate at which they feed units into the line. Here it can be seen how the unobstructed floor area available in the building is used to the best effect to give the large measure of flexibility required.

In addition to making and maintaining all the tools and equipment used in the works a large tool room is also responsible for supplying special parts to a prototype section under the control of the development engineers. In the production machine shop visitors will be able to see some interesting multi-spindle drilling machines which have been designed at the works and built in the tool room. Associated with the development section is a well-equipped mechanical testing laboratory for structural materials and a chemical laboratory for corrosion research, paint testing, &c.

Owing to space restrictions we cannot give particulars of any of the vehicles made by the firm in this supplement, but would draw attention to a description of one of its interesting military vehicles which was published in our issue of June 4, 1954.

Philips Electrical Industries, Ltd.

At the works of Philips Electrical Industries, Ltd., members will be shown some of the departments concerned with the manufacture and assembly of electronic, radio, and television equipment, valves, electric light bulbs, &c. The company owes its origin to Frederik Philips and his two sons, Gerard and Anton, who started a small electric lamp manufacturing concern in a make-shift factory in Eindhoven in 1891, with about thirty employees. It now employs over 95,000 hands, in factories situated not only in Holland but also in many other countries.

The factory first used by Mr. Gerard Philips for the manufacture of electric lamps has been retained in its original state amongst all the modern buildings now used for production purposes, and it was decided a short while ago to adapt the interior for a demonstration laboratory mainly for lighting engineering equipment. This laboratory has been equipped to show the many aspects of modern lighting and its applications in the home, industrial establishments, shops, schools, &c. Visitors will also be shown the demonstration studio for sound recording and reproduction, and for sound film production, which is used by the firm's electro-acoustics department.

Visitors will see assembly lines for radio and television sets such as that illustrated on this page. On these lines the sets are progressively assembled as they pass from operator to operator. Each operation is arranged to take a definite time to ensure that progress of the sets along the line is steady and that the standard of work can be thoroughly checked at inspection points without interruption of the smooth flow of finished units from the end of the line. The attention to minute detail in planning the operations on these assembly lines will be evident to all who are interested in mass production and factory layout. To those who are interested in fine assembly work and dexterity of operators the most fascinating department visited will be that engaged on electronic tube assembly. Here the minute parts are assembled step by step by skilled operators using interesting and ingenious fixtures.

The visitors will find an interesting contrast to tube assembly in the highly mechanised lamp-making departments where only a minimum demand is made on human effort. Here all parts for the lamps are made on automatic plant, the only manual work being the feeding of the machines and the inspection of the finished lamps.

A fourth party of members of the Institution will spend the day at the works of the Royal Netherlands Blastfurnaces and Steelworks, Ltd., at Ijmuiden.

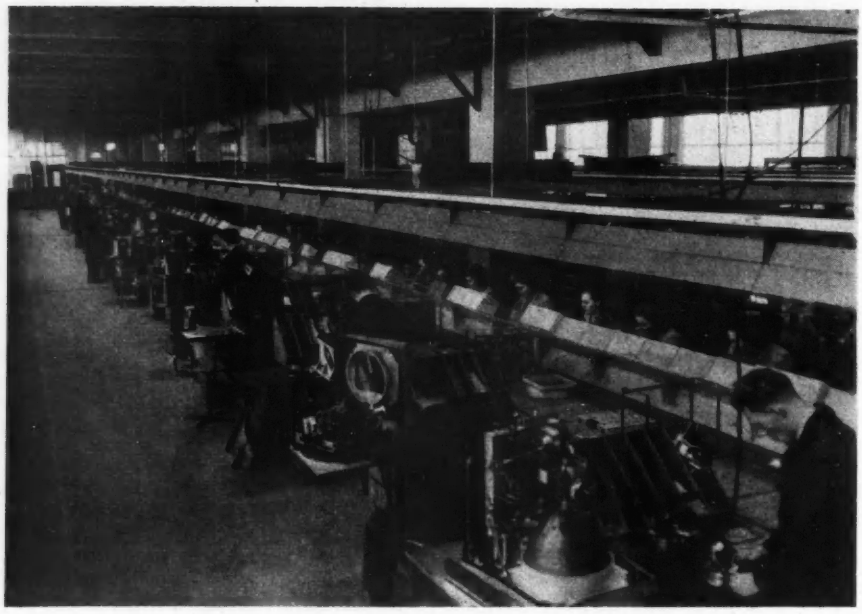


Fig. 18—Belt assembly of television receivers at Philips Works

Royal Netherlands Blastfurnaces and Steelworks, Ltd.

This works was opened soon after the end of the 1914–18 war and one of its largest extensions in recent years is a new rolling mill for strip and tinplate. Raw materials are delivered directly to the works by barges and sea-going vessels and the unloading facilities with the works in the background can be seen in Fig. 19.

Some general notes on this works and its products were given in our issue of October 23, 1953, in connection with the visit of the members of the Iron and Steel Institute.

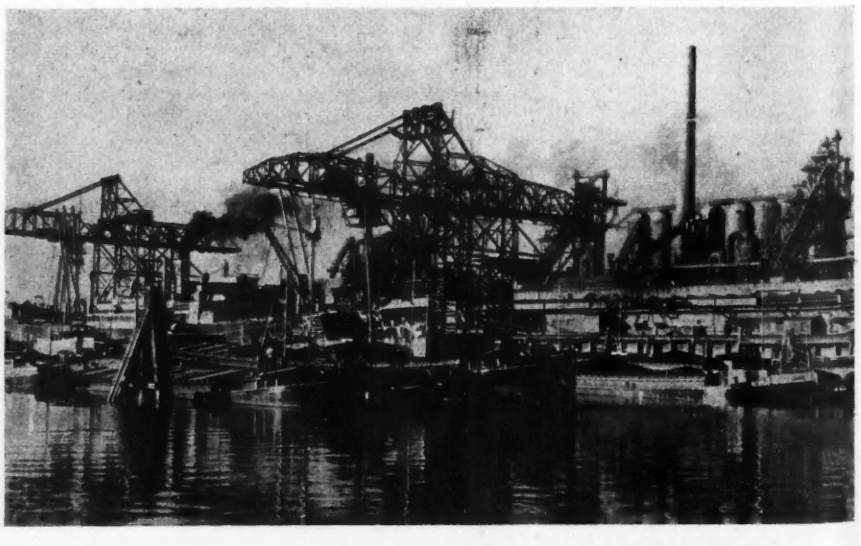


Fig. 19—Raw materials unloading equipment for the Netherlands Steel Works

PART II—DUTCH CIVIL ENGINEERING ACCOMPLISHMENTS

SEA DEFENCES IN HOLLAND

HOLLAND is noted, above all, for the reclamation of land from the sea, an art which has been practised in that country for many centuries. Twentieth century plant and methods in civil engineering have given a great impetus to the progress of reclamation schemes, and the modern Dutch techniques are well illustrated by the extensive repair works which have been in progress now for nearly a year and a half in South-Western Holland. After the disastrous storm and tidal surge which occurred at the beginning of February, 1953, a vast deployment of civil engineering resources was effected to repair, as quickly as possible, the extensive damage to the dykes. Other civil engineering works—in particular those in which floating plant was employed—had to be slowed down or stopped so as to have all the sea defences in a strong enough condition, by the autumn of 1953, to withstand the next winter's gales.

The problem of repair and reinstatement was thus governed by similar principles as obtained along the East Coast of this country in 1953. In fact, the mechanism of the formation of breaches in the dykes was considered by Dutch engineers to be the same as experienced along the East Coast of England, such as was described in our articles on the British sea defence works of the same period (THE ENGINEER, December 4, 11 and 18, 1953, and January 1, 1954). This aspect of the damage will not, therefore, be elaborated here, save to mention that the majority of the failures were caused on the landward side of the dykes, as British experience would have predicted. The chief interest of the Dutch works, therefore, lies in the actual methods of repair, which, owing to the particular circumstances, were very different from British methods.

An idea of the extent of the flooding in Holland in February, 1953, and of the damage to the dykes, is given by Fig. 20, although the marking of " breaches " in that illustration is not an exact process, for in some cases the breaches were so close together that a long length of dyke was virtually destroyed. That the tidal conditions at that time were markedly abnormal may be seen from Fig. 21, which shows the tidal levels over a considerable period at Rotterdam and the Hook of Holland. Comparison with the tidal levels plotted for the same dates at Southend, which we gave in our issue of December 4th last, shows that the initial peak of the surge was greater in Holland by almost 3ft than at Southend, and that an appreciable surge was experienced on the Dutch coast over three high tides, so that it was much more prolonged than on the English coast. Some figures may be given to illustrate the severity of the floods. In Holland, a country which has a population of 10,000,000, 1789 lives were lost, about 500,000 acres of land were flooded, well over half of them for a long period, and the subsequent repair works are to cost about £35,000,000 to complete ; the total cost of the damage done was estimated at £100 million.

The two breaches on the banks of the River Hollandse Ijssel, marked *A* in Fig. 20, were potentially the most dangerous of all the breaches on the Dutch coast. For, if they had been allowed to deteriorate, the central area of Holland between Rotterdam and Amsterdam would have been flooded, with even far greater destruction and dis-location than was actually experienced. Prompt action was therefore taken, and these two breaches, with widths of 8m and 45m, were closed on February 1st. Ships were sunk in them and sufficient of the clay at the base of these breaches held at the first low water for sandbags to be thrown in, without being washed away. Speed was essential in the repair work, particularly in the tidal breaches, for they worsened rapidly under the scouring of tidal ebbs and flows. Twenty tidal breaches were closed in February, and fourteen in March. But the most severe breaches took longer to deal with and the last of them was not closed until November. Reinstatement of tidal and

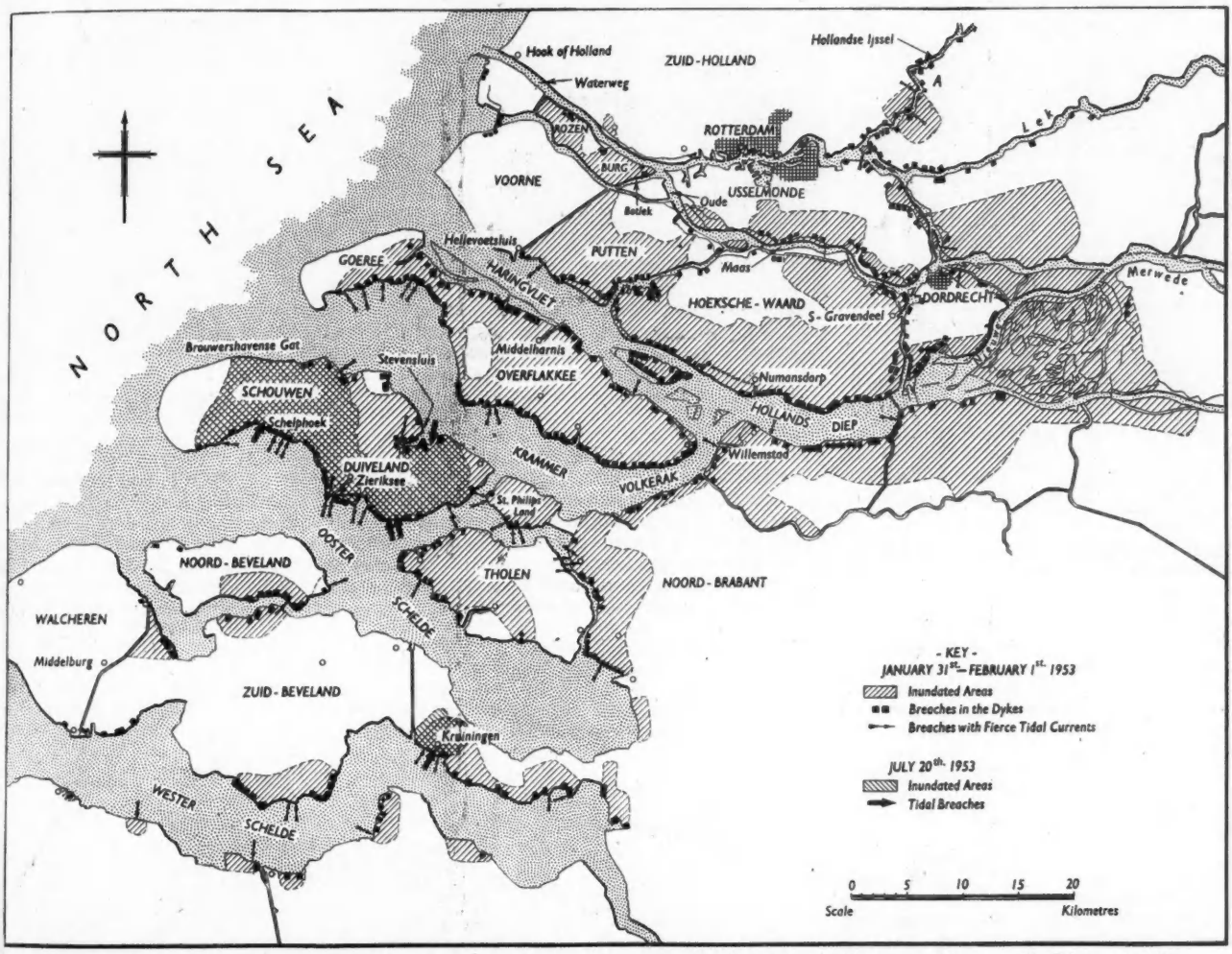


Fig. 20—Flooding in South-Western Holland and breaches in the sea dykes caused by the storm and tidal surge of January 31 - February 1, 1953

non-tidal damage was carried out by different methods, and it is convenient to take as typical examples of all the work an instance of the repair of each kind of damage. This can be done by describing the work on two of the islands—Schouwen-Duiveland and Goeree-Overflakkee, which, from their natural conditions, gave rise respectively to these two categories of reconstruction.

Tidal Breaches on Schouwen-Duiveland

By July 20th of last year all except the worst of the tidal breaches had been closed and flooded areas remained only at Kruiningen (Zuid-Beveland) and on Schouwen-Duiveland, as indicated on Fig. 20.

The largest breach was at Schelphoek, on the north-west of Schouwen-Duiveland, where the tide was passing freely through a length of 500m where the dyke was destroyed. The closure of this gap was the most formidable undertaking of all the repair work, and we

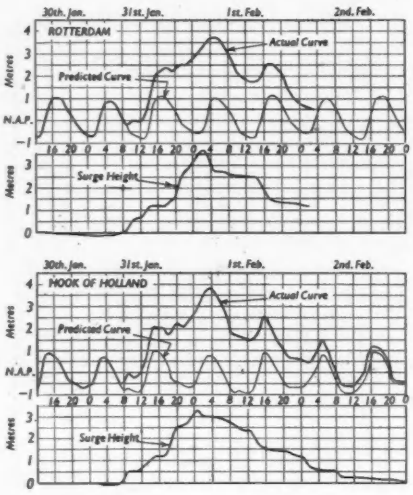


Fig. 21—Predicted and recorded tidal levels at Rotterdam and the Hook of Holland, January-February, 1953

propose to describe it in some detail. Schouwen-Duiveland is one of the older and lower islands, much of its area varying between 1m and 1·8m below the mean sea level (or N.A.P., as it is designated) with an average level of about −1·5 N.A.P. The town of Zierikzee, the principal town, is partly situated on higher ground and there are extensive sand dunes at the northern tip of the island. Generally, the dykes along the island's coast have been built up to levels of +6m to +8m N.A.P. on the northern side, where exposed to the full wave action of the North Sea, and to +5m to +6·5m N.A.P. on the southern and more sheltered parts. The peak level of the surge last year was about +4·32m.

It so happens that there are relatively few intermediate dykes on the island, and the polders are therefore large. The breach at Schelphoek was thus able to inundate an area of about 24,000 acres north of Zierikzee (the area is shown in Fig. 20). As the land level is about equal to low water of a spring tide, it will be appreciated that considerable scouring occurred through the breach. The quantity of water flowing in and out at each tide was estimated to be 120×10^6 cubic metres.* As time passed enormous gullies were scoured out in the soft sand and clay of the land near the

* This figure is, very approximately, four times larger than the capacity of the Queen Mary reservoir, the largest reservoir of the Metropolitan Water Board.

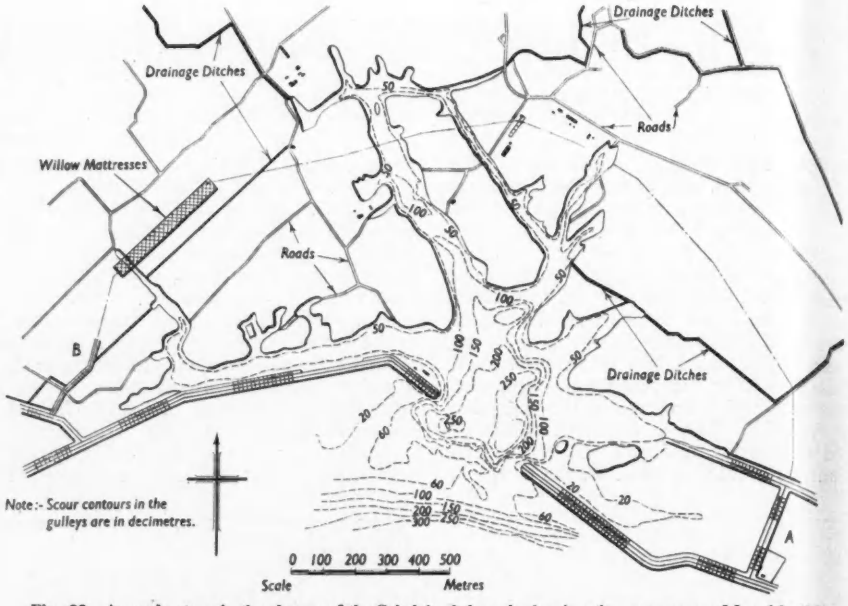


Fig. 22—An early stage in the closure of the Schelphoek breach showing the progress on May 16, 1953. The first of the willow mattresses are in position and the line of the closure dyke is indicated

breach. The growth of these gullies is indicated in the first illustration of the sequence of operations in the region of the breach (Fig. 22); they attained a maximum depth of about 30m to 40m, where the scour was most severe, and grew at rates of up to 40m a day.

All of the large breaches still left open in July were closed with the aid of reinforced concrete caissons, which were floated into position and then sunk on to prepared beds consisting of willow mattresses weighted with stone. This method of closure was first used in Holland after the war in closing the breaches in the island of Walcheren (see The Engineer, March 15, 22 and 29, 1946) and the method has proved very useful in the recent emergency. Closure of the Schelphoek breach, however, called for a more extensive use of caissons than elsewhere. To close the breach a "horseshoe" dyke, 4000m (2½ miles) in length was constructed round the landward side of the breach. Fig. 22 shows diagrammatically the first stage in the construction of this dyke.

Floating plant was able to work inside the breach, and a very considerable concentration of such plant was brought into use as the work proceeded. First, the small breach in a subsidiary dyke (marked *A* in Fig. 22) was closed, and a small clay wall *B*, built by a floating crane operating a clamshell grab, was built out from the other side of the breach for a total distance of some 300m. The tidal currents were smallest in this area, thus permitting the construction of a bank in sand and clay. The clay bank was built up to about +2m N.A.P. and then sand was pumped by a suction dredger and discharged behind it; the sand settled to a slope of about 1 in 30 up to nearly the top level of the clay bank. It was then possible to use draglines and bulldozers to shape the sand to form a dyke with a top level of about +4m or

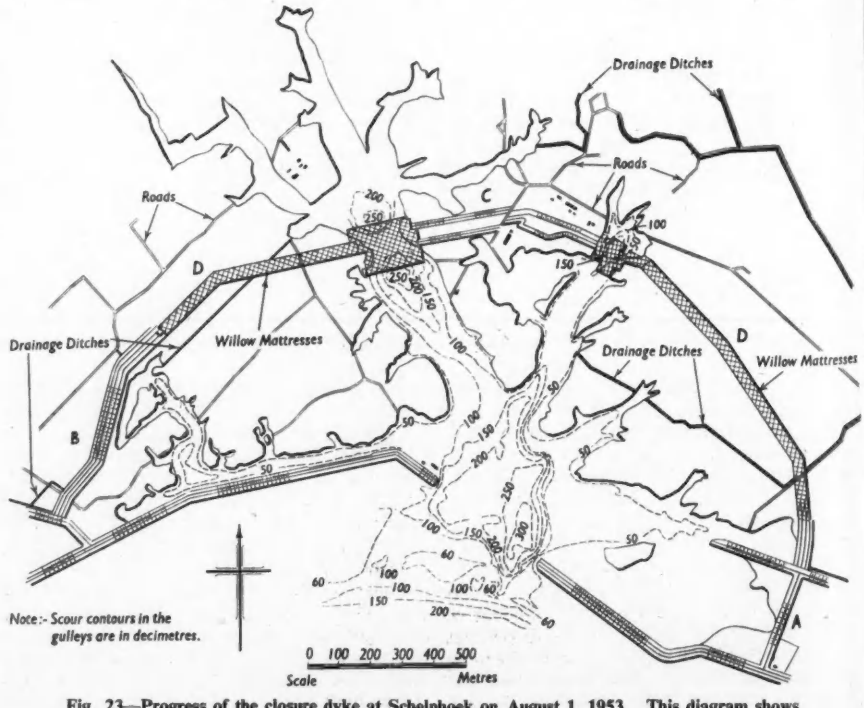


Fig 23—Progress of the closure dyke at Schelphoek on August 1, 1953. This diagram shows all the mattress work completed ready for the emplacement of caissons

+5m, which was then consolidated by covering it with clay.

A similar construction was used for a very short length at the other end of the "horseshoe" and also in the centre between the gullies. But here the tidal currents were stronger and two clay training walls were built to enclose an area and the sand then pumped into it. This work is shown extended to its full extent in Fig. 23 at *C*. The siderable barrier to the tidal flow was offered when they were in position, with consequent increases in its velocity. The maximum velocities of flow across the line of the new dyke was thus about 4½m per second. Nevertheless, the mattresses were of sufficient size to prevent excessive scour and to provide a fairly stable base for the caissons.

In the gullies conditions were more complicated. Mattresses 120m in length and 20m

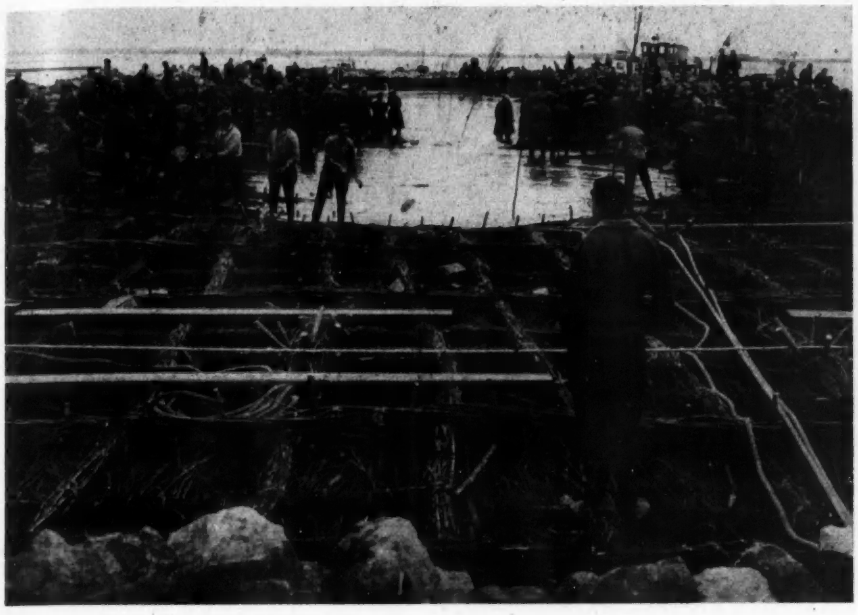


Fig. 24—Willow mattress being sunk into position at the Schelphoek breach by loading with stone. The construction of the mattress can be clearly seen in this illustration

finished dyke was covered with clay as before. This central dyke was made rather wide and it served as a convenient base in the centre of the work.

Whilst this construction was in progress willow mattresses were built for emplacement along the line of the new dyke and in the gullies. The construction of these mattresses is well illustrated by Fig. 24, which shows stone being placed on one of them to sink it in position. Except at the gullies, mattresses 40m square were used. The thickness of a mattress plus the stone weighing it down was about 1m, so that a con- in width were placed and sunk into position, following the shape of the gully bottom. But scour was, of course, induced at each end of a mattress, deepening the gully still further. In some cases, therefore, several mattresses were placed overlapping or on top of each other and, as Fig. 23 indicates, it was necessary to cover a large area with them to get sufficient stability. Considerable quantities of stone were placed on the mattresses to build them up sufficiently and to make a level base for the caissons. In the largest gully caissons were sunk in position on each side, and it was closed by placing a "Phœnix" caisson—previously used in France for the wartime Mulberry Harbour and supplied by the Royal Navy—in the centre. This caisson was 60ft deep, 200ft in length and 60ft in width, and was placed at the slack water of low tide to close the central gap left between the smaller caissons in the gully.

The smaller gully was closed in a similar manner, and then caissons, each 66m long by 7½m wide and 3m high, were placed along the two lengths *D*, Fig. 23, where mattresses were already in position. About 200 of these caissons were needed. They were placed at the slack water of the high tide; two stagings were anchored by piles near the final position of the caisson, equipped with winches and the caisson was positioned from them. Seven caissons, totalling 460m in length, were placed on August 26th, the best day's progress recorded, and on August 27th the last caisson was placed. The cross current was so strong that each caisson had to be filled with sand immediately it was in position.

With all the caissons in position the breach was still not watertight, for there was considerable flow through the stone layer under the caissons. A clay bank was next built in front of the caissons and sand pumped behind them. With sufficient sand in position, the finished profile was formed and then covered with a layer of clay, as shown in the upper drawing Fig. 25. The clay face of the dyke was revetted with timber fascines for wave protection.

The cross section through the centre of the large gully (Fig. 25) illustrates how the dyke was completed at that point. The successive positions of the mattresses at different dates illustrates our earlier remark on the scour in the gullies. It will be seen that, with the caissons in position the gullies were filled with sand—a very considerable quantity was required—and a dyke with a clay covering was formed to complete the work.

Basalt pitching is specified for the seaward slope of the eastern part of this new "horseshoe" dyke at Schelphoek, as shown in Fig. 25. An asphaltic facing is specified for the western part with stone pitching at the toe. This facing work remains to be completed this summer. The asphaltic construction is analogous to that described later on, but it may be noted here that the basalt pitching is much favoured in the Netherlands for this class of work; the stone, which is

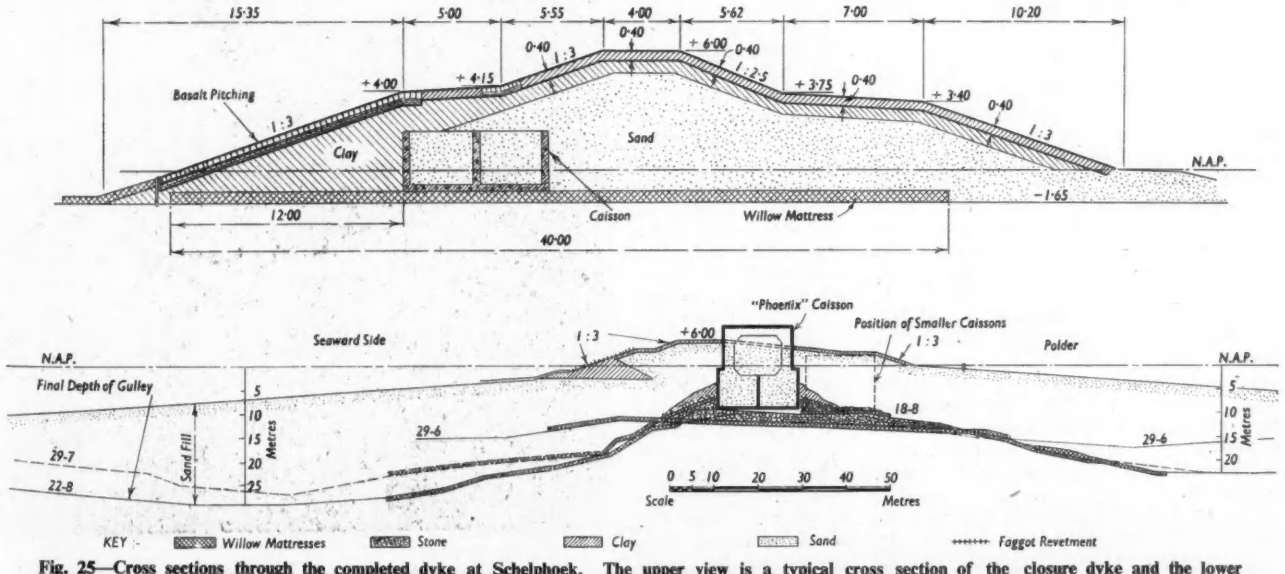


Fig. 25—Cross sections through the completed dyke at Schelphoek. The upper view is a typical cross section of the closure dyke and the lower view is a cross section through the main gully. The extent of the scour in the gully is indicated in the lower view by the different positions taken up by the willow mattresses, against each of which a date is given

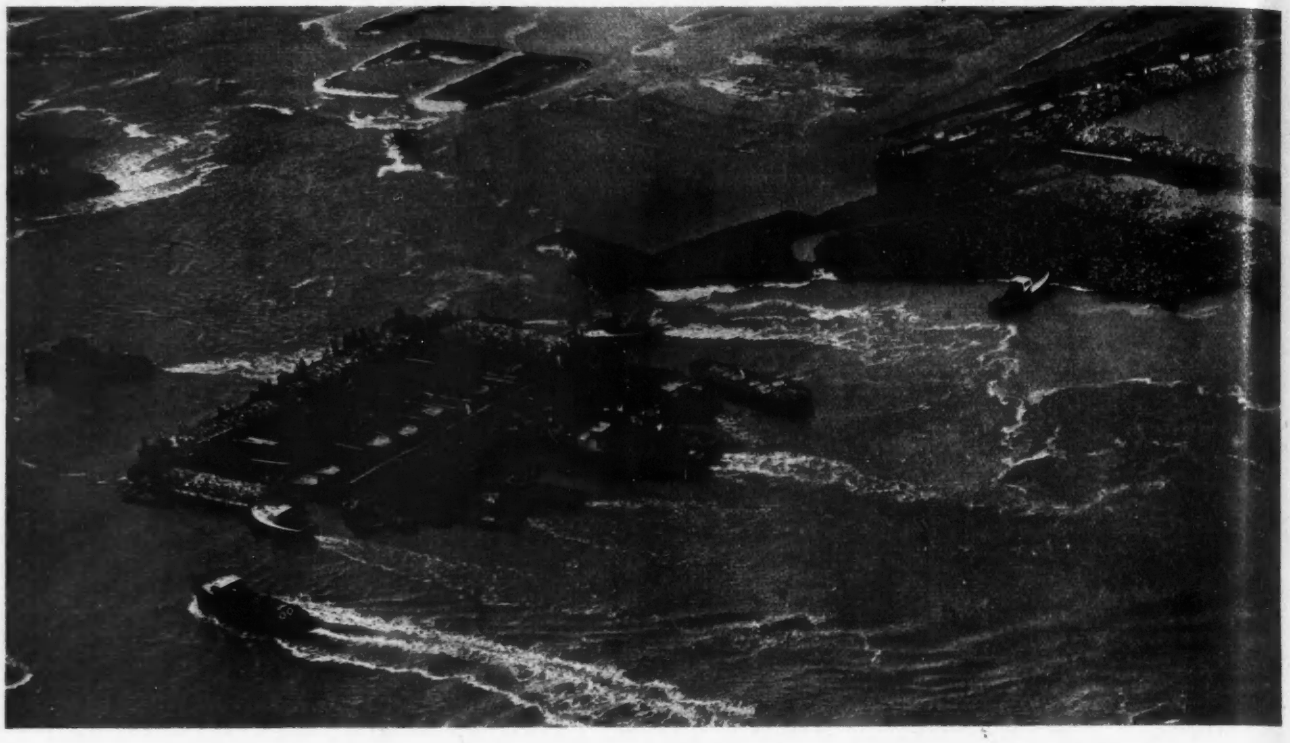


Fig. 26—Towing willow mattress into position for construction of the closure dyke of the Schelphoek breach

imported from Germany, has a high density, and gives a revetment which, in Dutch experience, weathers sturdily and needs little maintenance.

The earlier and more critical stages of the work—that is, before the breach was sealed off—are shown in progress in Figs. 26 and 27.

A willow mattress is shown being moved into position in Fig. 26, and a bird's eye view of most of the closure dyke is given in Fig. 27. In this illustration the breach in the original dyke is not shown, the seaward side of the "horseshoe" closure dyke being to the right. The large caisson in the main gully is clearly shown, with the smaller standard caissons in position in the foreground. The reclaimed area in the centre of the dyke is also shown, and in the background the caissons are still to be placed in position, but the line of the mattresses and the stone tip is clearly marked by the tidal currents.

The closure of the Schelphoek gap accounted for an expenditure of about £3,000,000. A very considerable concentration of plant was necessary and, with the other breaches on the island 5000 men were employed, together with a fleet of some 200 floating cranes, tugs, launches and other craft, nearly 300 barges of various kinds and about forty dredgers; the land-based plant included about 100 draglines, several bulldozers and other plant. The board of the Zuiderzee Works (Zuiderzeewerken)—a state authority—was responsible for the work on Schouwen-Duiveland. The leading contracting firms were: Aann.Comb. Schouwen-Duiveland, Zierikzee; Aannemersbedrijf Zanen Verstoep N.V., The Hague; Aann.Comb Z.Z., The Hague; Aannemersbedrijf v.h. J. P. Broekhoven N.V., Arnhem; Aannemersbedrijven van Oord, Utrecht en Werkendam; Aannemersbedrijf J. van der Vlies, Sliedrecht; Aannemersbedrijf den Breijen en Geluk, Gorinchem.

The severest tidal breaches made in the Dutch sea defence dykes were all closed by similar methods to those described above for the Schelphoek gap, on the island of Schouwen-Duiveland. The last four breaches which were closed are indicated in Fig. 20. At Kruiningen, a "Phœnix" caisson was used, and again on Schouwen-Duiveland four such caissons were used to close the breach at Ouwerkerk; the first attempt to close the Ouwerkerk breach, using smaller caissons, had failed and several caissons had been washed out. The breach at Stevensluis was closed with smaller caissons, but employing the same general procedure as is clearly shown in Figs. 28 and 29, where the willow mattresses and caissons can be clearly seen. Several other breaches, for instance, near the harbour mouth at Zierikzee, were closed with caissons, but for the smaller tidal breaches more traditional methods were employed. These methods were all based on the use of willow mattresses, as already described, to give scour protection and a flexible base in the first stage of closure. With the mattresses in position it was possible to dump stone to form a dyke which could then be sealed with clay. A breach 120m in length was closed by this method at Oosterland on Schouwen-Duiveland by placing 15,000 tons of stone. Alternatively, additional mattresses may be added on top of the original ones—this is the classic Dutch procedure—and the dam so formed topped with sandbags or a fascine crest. Some of the local clays are resistant to scour and may also be utilised and, in fact, clay was imported from the Hollandse Deep area for the works at Schelphoek. Sand pumping methods were also utilised for a number of the tidal breaches using similar procedures to

Fig. 27—The Schelphoek breach. The central reclaimed area shown in Fig. 23 and the disposition of plant and jetties may be noted

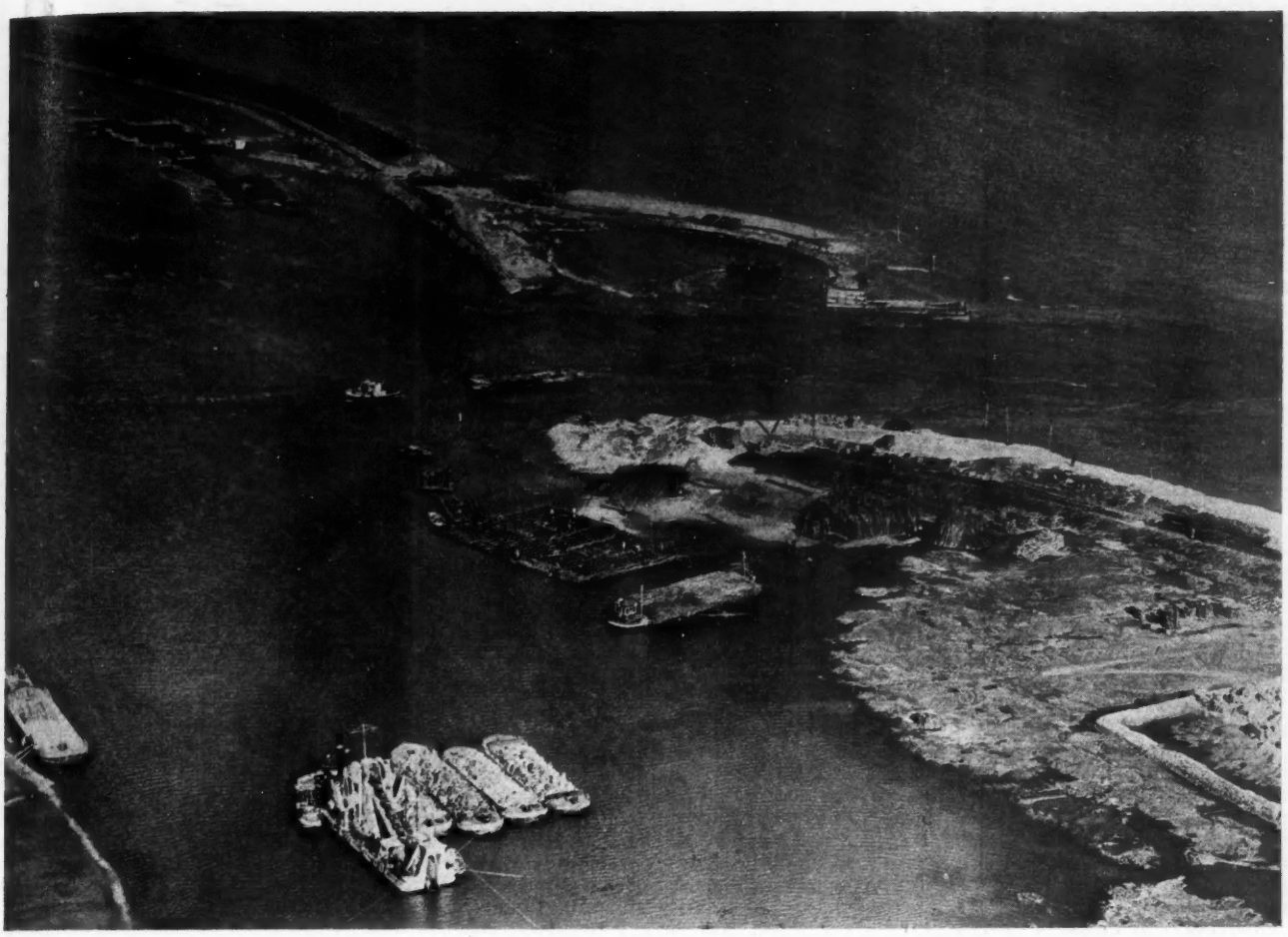


Fig. 28—The Stevensluis breach on the east coast of Schouwen-Duiveland. A willow mattress is shown being assembled close to the breach

those already touched on in the description of the Schelphoek works.

Dyke Repairs on Goeree-Overflakkee

The repair of non-tidal breaches in the dykes was not, of course, such hazardous work as that already described. But it presented problems of its own which required no little skill in their solution, as will be apparent from the ensuing notes describing the works on the island of Goeree-Overflakkee. Much of the land on this island has been reclaimed in more recent times than the land of Schouwen-Duiveland. The average level over much of the island is about mean sea level (N.A.P.), and the dykes round the coast are built to +4·5m or +5·5m N.A.P. Generally, the foreshore in front of these dykes is formed as a pitched berm at a level of about +2m N.A.P. for an appreciable width ; as the normal high spring tide level is about +1·5m N.A.P., the protective effect of this berm may well be appreciated. Altogether about a dozen tidal breaches were formed, of which four were major ones ; two of them were so located that the tidal currents cut the island in two. Several miles of dykes were destroyed. This island is divided into many small polders by the internal dykes, which generally have a top level of about +3m. Those tidal breaches which occurred on the island could thus be dealt with by closing, successively, the gaps in the secondary dykes, thus limiting the extent of tidal flooding until a relatively small area next to the main breach was left, with a comparatively small and weak tidal flow passing through it. Repair was then a much simpler matter.

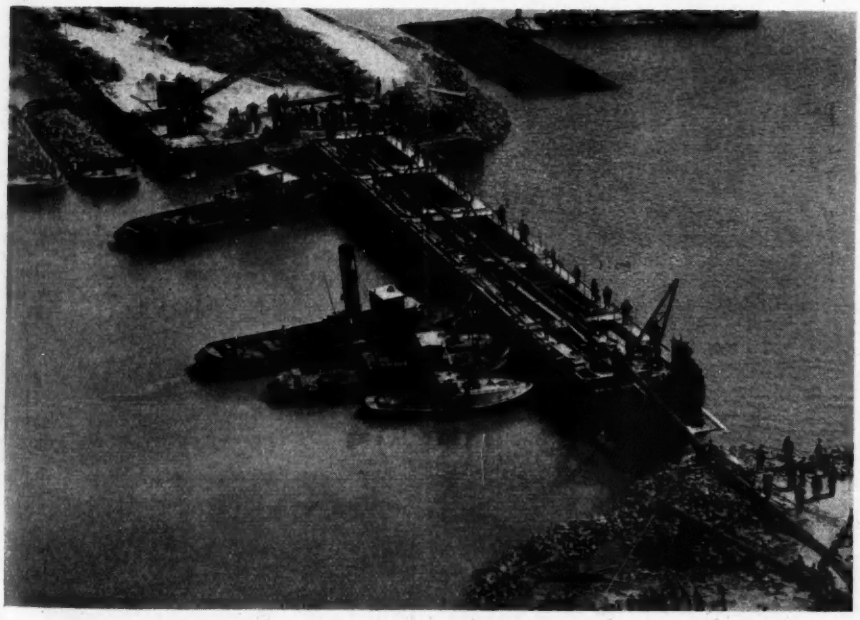


Fig. 29—Placing the closing caisson in position at the Stevensluis breach. Preparatory works such as stone pitching and smaller caissons may be observed on each side of the final gap

On the northern side of the island, which is exposed to the full wave action of the North Sea, the dykes have generally a greater additional height above surge level than on the southern coasts, which are more sheltered. This small extra height made an appreciable difference to the damage caused last year, most of which was on the more sheltered coast ; the surge reached a level of about +4·5m. The new dykes have generally been built to +5·5m or +6·5m N.A.P.

The greatest problem to be faced in February of last year was therefore the amount of work which had to be done before the next winter. About 22km of the outer dyke on the coastline had been, for all practical purposes destroyed, and severe damage had been done to a further 25km. The prin-

cipal works were thus the rebuilding of about 18km of dyke on the south-western coast of the island and of a length of about 4km on the north-eastern side close to the island's principal town, Middelharnis. There was only one method by which this work could be completed in time, namely, by placing sand fill hydraulically, shaping it to form the dyke, and covering it with an asphaltic surface. Sufficient clay or stone were not available for the use of more conventional methods of construction (although these materials were used for the reinstatement of other lengths of dyke, where the quantities concerned were

weight of the sand fill could be computed, and the quantity of sand needed to bring the dyke to its ultimate top level deduced.

Floating plant was again extensively used for this work. Most of the south-western coast of the island is fringed with mud flats, and craft could come close inshore only at one or two places. The work was therefore centred principally on two coastal bases and three floating sand pumping stations, one at the eastern end of the work and two at St. Jacob's Hook, about 12km further west, where jetties were constructed. Sand was dredged at sea and brought by barge to the

of 3 : 1 and its toe is at a level of +2m N.A.P.; it is finished with timber sheet piling, with stone revetting in front of it. The top of this dyke is at +5·5m N.A.P.

Repair work on the island has also included the establishment of a rational system of second-line dykes, from the patchwork of the old internal dyke system. Clay has been borrowed from those old dykes which have been superseded to reinforce those selected to form the new second line barrier. The sand dunes at the northern tip of the island were badly eroded by the 1953 storm, 30m to 40m of dune being eroded in some places.

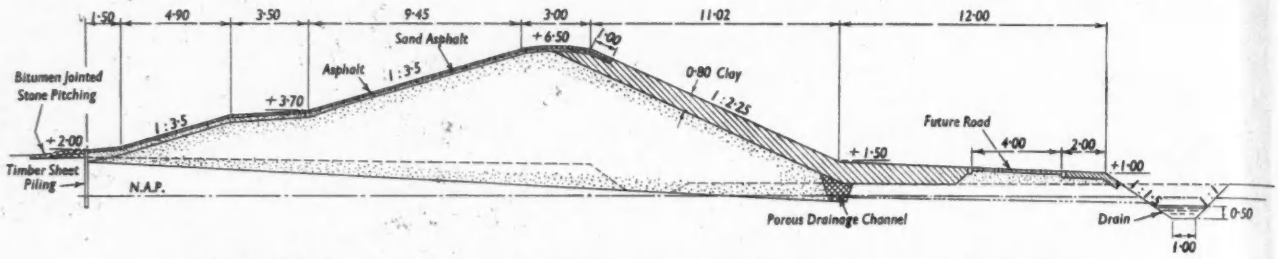


Fig. 30—Typical cross section of the hydraulically placed sand fill dykes on the island of Goeree-Overflakkee

much more modest) and the handling capacity of the small island harbours was much too limited. It was therefore decided to cover the graded sand dyke with a layer of "sand-asphalt," a mixture consisting of 84 per cent of sand, 8 per cent of bitumen, and 8 per cent of filler. Sand-asphalt had been used previously in Holland, with success, on the sea defences of several harbour sites, but in these cases there were no people living behind the dykes, whose safety was at stake if they failed. But circumstances forced the decision, and engineers in many countries will watch with interest the behaviour, over the years, of the considerable length of dyke of this kind on Goeree-Overflakkee.

A typical cross section through the dyke is shown in Fig. 30. The method of construction was as follows. Two clay retaining dykes were constructed by dragline or other excavator, spaced about 50m apart and with a top level of about +3·5m N.A.P., along the proposed line of the new dyke and with cross walls built between them at intervals. Sand was then placed hydraulically to fill the enclosures formed by the clay banks.

With the sand fill in position the finished profile of the dyke was formed with excavators, mostly draglines, and bulldozers. The seaward face was protected by placing the sand-asphalt layer shown in the cross section and the rest of the sand surface was covered with clay. The clay bank on the landward side, which stood clear of the completed profile, was used to form the clay surface. The corresponding clay bank on the seaward side was spread out to reinstate the berm along the foreshore, which had suffered erosion at the time of the storm.

It will be seen that the completed dyke includes a drain on the landward side, which was included in the design as a result of seepage tests carried out on a model. Soil mechanics tests were made on the underlying formation so that its settlement under the

pumping stations at the jetties. Pipelines were laid along the coast, with booster stations at intervals, so that sand could be pumped all along the job, the maximum length of pipeline being about 5km. Altogether four booster stations were used, two of them in the longest pipeline. Bitumen was also brought to the jetties by lighters. Large quantities were needed and will be required again this summer, for the final asphalt layer shown in Fig. 30 is being constructed this year. The sand-asphalt has thus successfully withstood last winter's weather. But the stronger, conventional asphalt is needed to give permanent protection from the weather. Chippings are spread on this final asphalt layer; on the landward side the clay is turfed to give similar protection.

For the work this summer two large installations of bituminous mixing plant are again in operation at St. Jacob's Hook, and at the eastern end of the work, with a capacity of 120–150 tons per hour of mixed asphalt. The quantities involved in completing the 22km of dyke reconstruction are 170,000 tons of sand-asphalt and 100,000 tons of asphalt, containing roughly 30,000 tons of bitumen. The corresponding quantity of sand fill in the new dyke is 3,000,000 cubic metres, which was placed at a rate of some 20,000 cubic metres per day (i.e. about 150m of dyke). The quantity of bitumen in the finished work amounts to less than ½ per cent of the total volume, for the sand-asphalt, as already mentioned, contains only 8 per cent of bitumen. Furthermore, it remains to some extent plastic, and is able to accommodate itself to the inevitable settlement of the dyke.

The 4km of new dyke on the north-eastern side of the island was built by the same method—hydraulically placed sand covered with sand-asphalt, but the final asphaltic coating was constructed last year. It has the same cross section as the new dyke on the south-western side with a seaward slope

A new embankment is being constructed, cutting off certain areas of dune to give a straighter, more economical line of defence; it consists of sand, graded and faced with sand-asphalt.

The cost of the reconstruction works on the inner and outer dykes of Goeree-Overflakkee will total about £6,000,000. As with the other works it is almost entirely State subsidised. It is being carried out under the technical direction of the provincial water board of South Holland, in collaboration with the local dyke authorities. The contractors who carried out the works are Aannemingsbedrijf Oosterwijk N.V., of Rotterdam; Van Hattum and Blankevoort N.V., of Beverwijk, and R. Boltje and Zn N.V., of Zwolle. The bituminous work has been sub-contracted by these firms and is being carried out, on the various sites on the island, by Koninklijke Maatschappij Wegenbouw N.V., of Utrecht; Hollandsche Beton Maatschappij N.V., of The Hague, and N.V. Aannemings and Wegenbouwbedrijf P.C. Zanen, of Heemstede. The bitumen is supplied by Shell Nederland N.V. The restoration of the sand dunes on the northern tip of the island is being carried out by the State Dyke Authority, the Rijkswaterstaat.

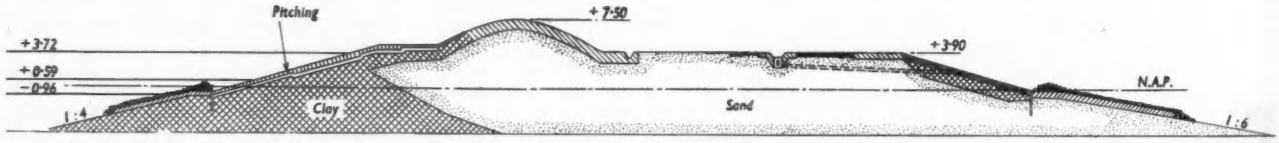


Fig. 31—Typical cross section of the enclosure dyke of the Zuider Zee. This dyke forms the first line of defence for the reclamation areas in the Ijsselmeer and has turned the Ijsselmeer into a fresh water lake

The "Delta" Committee

The severity of the storm and tidal surge of January and February, 1953, has led in Holland, as in this country, to a new appraisal of the efficiency of sea defence works. In Holland, where so much more depends on the sea dykes, possibilities of storm surges had not been overlooked by experienced engineers and meteorologists, but, again as in England, their warnings tended to go unheeded. In a lecture given at the Royal Institute of Engineers at The Hague, the Director-General of the Rijkswaterstaat gave his views on whether there had been any negligence or guilt. The maintenance of the dykes, he pointed out, rested with the local

"polder boards," under the supervision of the provincial authorities, the "Provinciale Waterstaat." Maintenance had not been neglected and the dykes were in an excellent state of repair, he said; their collapse was simply due to the fact that they could not resist a surge of such magnitude, with a probable frequency of occurrence of once in four centuries. That fact was known, he continued, but heavy sacrifices would have had to have been made with social and military measures if any remedial works had been undertaken. Furthermore, the warnings given of the possibility of storm surges tended to be regarded, he said, as "a joke of a few scientists shut up in their ivory tower."

But now the subject has been thoroughly investigated again and in March a report was published by the "Delta Committee," as it is called—a committee of eminent Dutch authorities with terms of reference analogous to our own Waverly Committee. The recommendations of the Delta Committee are of considerable technical interest, for they concern not only the question of storm surges, but also the development as a whole of the low-lying areas of South-Western Holland. These areas have not only to be protected from storm surges, but measures have to be taken to contend with the sinking of the land relative to the sea. This effect is appreciable (it is estimated to average 30cm in a century) and several causes have been put forward to explain it, viz, a sinking of the land of 18cm per century due to shrinkage caused by drainage and a rise of 12cm per century of the sea level, due to geological causes. We noted earlier that a great part of Schouwen-Duiveland lies at about low-water level of spring tides; thus the land drainage must all be pumped out of the island. But in earlier years, when the island was first reclaimed, it was at a higher level and pumping was not necessary. The sinking of the land brings with it a related problem, in that there is a tendency for the ground water, in coastal regions, to become saline, with consequent poisoning of the ground.

In considering all these problems the Delta Committee has proposed a bold solution, the general scheme of which is shown in Fig. 32. It is proposed to build dams across the sea channels between the islands, as shown on the map. A series of fresh water lakes, fed by the Rhine and the Maas, would be formed by this measure, thus solving the ground water problem, and, more important, the length of the sea dykes would be greatly reduced in the Holland-Zeeland archipelago from the present figure of 1100km. The new dams would have a total length of about 20km, and, of course, there would still be the outer coasts of the islands forming part of the first line of defence, but these coasts, it may be recalled, are fringed by substantial sand dunes.

The Delta Committee's scheme provides for leaving free access for shipping to the port of Rotterdam, with a dam marked *A* in Fig. 32 on the Hollandse Ijssel to protect the area mentioned at the beginning of this article, where the most critical breaches occurred. These proposals have other advantages, too. It would be possible to reclaim appreciable additional areas of land inside the sea dykes by the secondary dykes, also shown in Fig. 32, and road and rail communications to the islands, which are at present very isolated being served by ferries, would be greatly improved. The difficulty lies in the construction of the dams, the technical investigation of which is still to be carried out. The dams would be built in exposed localities, near the open sea, on a bottom of fine sand and at depths of 30m and 40m in strong tidal currents. Whether or not these proposals will prove practicable remains to be decided, for the Delta Committee's report has not yet been adopted by the Dutch Government.

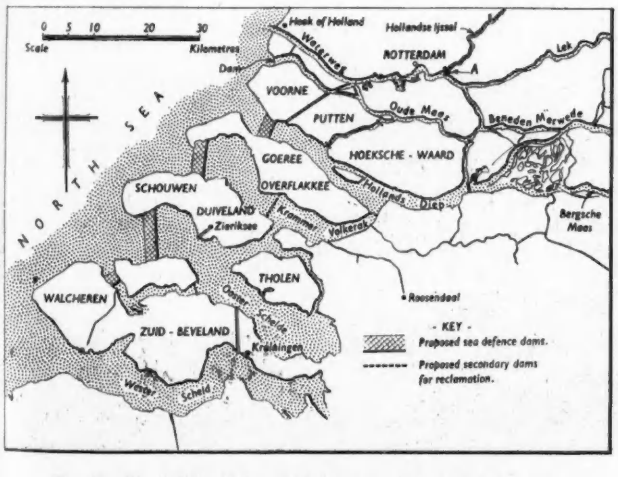


Fig. 32—The "Delta" Committee's proposals for sea defence and reclamation works in South-Western Holland

Reclamation of the Ijssel lake after completion of the enclosing dam :
1. Wieringer-Meerpolder, 50,000 acres, 1927–1930.
2. Trial polder, 100 acres, 1927.
3. Proposed Markerwaard polder, 133,000 acres.
4. Proposed Flevoland (Southern) polder, 110,000 acres.
5. Flevoland (Eastern) polder, 133,000 acres, at present under construction.
6. Noordoost polder, 119,000 acres, 1937–1942.

Earlier reclamation works in the area :—
7. Koegras, 1824.
8. Anna Paulowna, 1847.
9. 1599.
10. 1456.
11. Heerhugowaard, 1631.
12. 1564.
13. Schermer, 1635.
14. 1608.
15. Beemster, 1612.
16. 1683.
17. Wormer, 1626.
18. Purmer, 1622.
19. 1628.
20. Ij-polders, 1872.
21. Haarlemmermeer, 1852.
22. 1427.
23. c 1200.
24. 1280.
25. Leeuwarden, 1400.
26. 1600.

Fig. 33—Reclamation in the Ijssel lake. Those polders already reclaimed and those proposed are shown, and the legend gives details of earlier reclamation works in the area

The Zuider Zee Dyke

These proposed works bear a resemblance to the Zuider Zee reclamation, and it is doubtless the successful experience gained with that project which has led to their consideration. A few words may therefore be added here on the Zuider Zee works, which are to be visited by the members of the Institution of Mechanical Engineers during the Summer meeting.

The Zuider Zee dyke, construction of which was started in 1927, is not so deep as those proposed by the Delta Committee, but its substantial size may be gauged from the cross section Fig. 31. It is 30km in length and encloses an area of 3500 square kilometres, which has thus been transformed into a fresh water lake, solving the ground water problem in that area. Within the shelter of the first line defence that this dyke affords polders are being successively reclaimed from the Ijssel lake. Eventually 2250 square kilometres of the total area will be reclaimed. At the moment the total figure for the land reclaimed in two polders is 600 square kilometres. A further polder—Eastern Flevoland, totalling 540 square kilometres—is being reclaimed and work will be completed by 1957. Three pumping stations are being constructed in the open water of the Ijssel lake, and dykes are being built by floating plant, with navigation locks included at two points. Before the polder is pumped dry dredgers will work across it and excavate the canals which are to be served by the navigation locks. These works are being carried out under the direction of the Zuiderzeewerken, a State body forming a department of the Rijkswaterstaat. A good idea of this work is given by Fig. 33, which shows the progress made in reclaiming the various polders in the neighbourhood of the former Zuider Zee, the plans for future reclamation, and the work at present in progress in that area.

AMSTERDAM-UTRECHT MOTORWAY

Holland is a densely populated country but its "population" of motor vehicles is comparatively small, numbering at present about one to every thirty-five inhabitants. In spite of that fact an energetic programme of road construction is being carried out, and the last section of a major element in the Dutch motorway system, the Amsterdam-Utrecht motorway, was inaugurated on April 1st. Some of the first European motorways were built in the Netherlands. The country's system of primary roads was planned in 1927, when a law for their development was passed, specifying limited access for motor vehicles only and certain standards of construction, and that the country's road plan should be reviewed every ten years. The first Dutch motor road was built as a four-lane highway from the Hague to Rotterdam but subsequent experience has shown the marked superiority of dual carriageways. These motorways have proved of great benefit to the country, giving fast travel between the principal cities and showing a very substantial reduction of accident rates. The most modern of them, the Amsterdam-Utrecht motorway, will now be described more fully, but for a general account of the Dutch motorways we would refer the reader to a recent paper presented by the chief engineer and director of the department of the Rijkswaterstaat concerned with roads, Ir. M. de Bussy, at the Institution of Highway Engineers.*

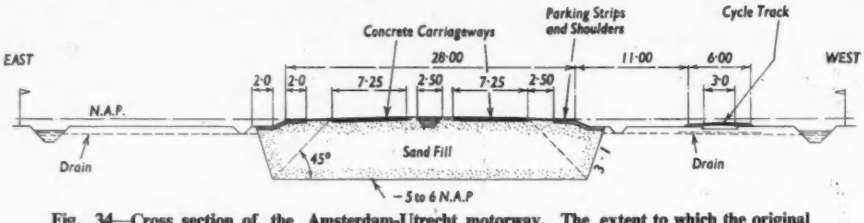


Fig. 34—Cross section of the Amsterdam-Utrecht motorway. The extent to which the original peats and silts have been replaced with sand is clearly shown

It comprises dual 7·25m carriageways totalling just over 32km in length, stretching between the Amstel canal—the start of the motorway on the south side of Amsterdam where a major road bridge has been built—to a roundabout junction with the Hague-Utrecht motorway just to the west of Utrecht. There is access to the motorway at six intermediate points, where "fly-over" crossings of various designs have been constructed. The bridges at these points are generally reinforced concrete structures of slender and neat appearance. The design speed of the motorway was 130km per hour, and sight lines of at least 250m were specified, with horizontal curves of, as a rule, not less than 2000m radius. Lay-bys, parking shoulders and cycle tracks are provided along its length.

The method of constructing the motorway is of particular interest, although it is not novel for Dutch conditions, and some of the earlier roads were built in the same way. The road passes over flat land, consisting of weak clay, silt and peat, too weak to support the road. A canal was therefore dug, along the line of the proposed road, by floating dredgers. Its depth was about 6m and its width about 30m. Natural deposits of sand existed at various points near the route of the new road, which were utilised to fill the canal and give a strong enough formation for the carriageways. Sand was excavated by suction dredger, and transported hydraulically to the canal until the latter was filled. The total quantity of sand involved was

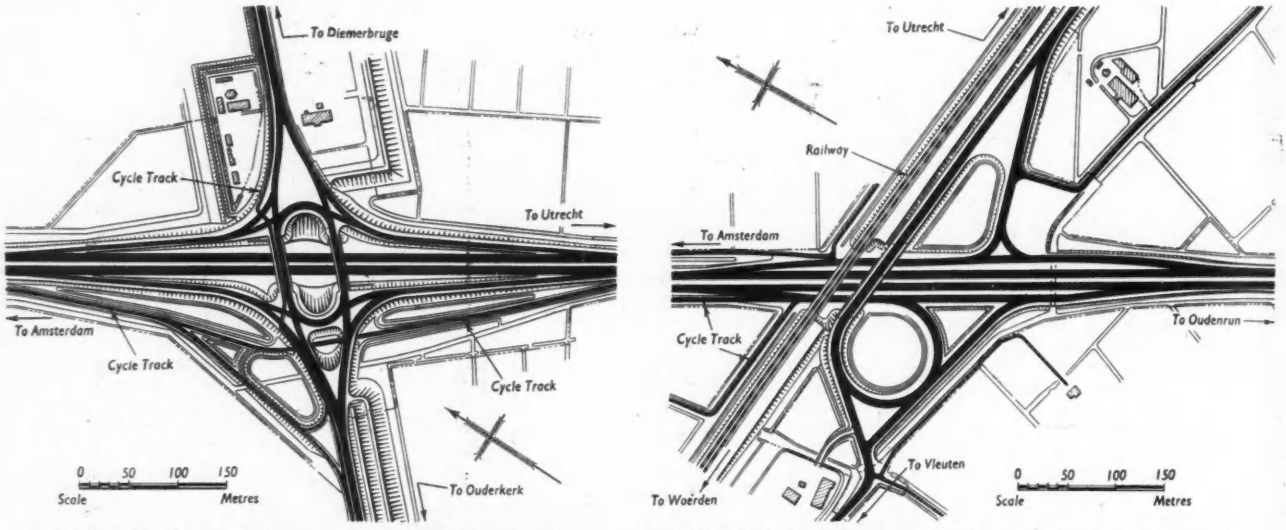


Fig. 35—Typical road junctions on the Amsterdam-Utrecht motorway. The left-hand diagram shows a minor road passing over the motorway and the right-hand diagram a combined road and rail overpass

The Amsterdam-Utrecht Motorway

The newest of the Dutch motorways, from Amsterdam to Utrecht, is undoubtedly the best of them and it sets a high standard.

Fig. 36—Prestressed concrete bridge over the Amstel canal at the Amsterdam end of the motorway. The opening ceremony was in progress when this photograph was taken

* "Roads in Europe," *Journal* of the Institution of Highway Engineers, October 1953, Vol. II, No. 12.

Fig. 37—An early stage in the construction of the motorway. The canal is being excavated by floating plant, in readiness for the hydraulic emplacement of sand at a later stage

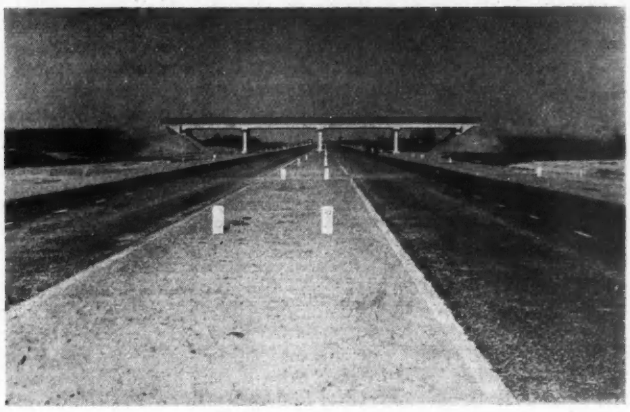


Fig. 38—A typical overpass structure of the Amsterdam-Utrecht motorway. The Ter Aaseweg crossing is shown here

8,000,000 cubic metres and large lakes have been formed near the new road, where the sand has been won. The cross section, Fig. 34, illustrates the method of construction.

As the sand fill was placed under saturated conditions, it required no consolidation. Concrete carriageways were constructed on the sand, using fully mechanised constructional methods — crawler-track-mounted, double-drum concrete mixers, and spreading and compacting carriages travelling along the side-shutters as the work progressed. Such plant is well-known in this country and need not be described further. The thickness of the concrete of the carriageways was generally 23cm and two classes of concrete were used, with the richer mix forming the road surface.

At points where structural works occurred and settlement of the finished carriageway was expected, due to the fact that the sand fill could not be placed hydraulically, or for other reasons, a traditional Dutch surfacing consisting of sand-faced bricks was used instead of concrete. These bricks give rather rough riding, but can accommodate a certain amount of settlement or can be readily regraded.

A typical crossing of a minor road—the crossing carrying the road to Ouderkerk and Schiphol, is shown in Fig. 35 (several crossings of this general design have been built), as well as a road and rail crossing near the south end of the motorway, where a branch road leads to Utrecht, approaching that city from the north-west.

The Dutch highway authorities estimate that the new motorway will save about 10,000,000 vehicle kilometres (that is, 17,000 vehicle days) and 2,000,000 litres of petrol in a year. This saving is computed to be equivalent to a tenth of the constructional cost of approximately £5,000,000. The accident rate of the motorway, for both fatal and non-fatal accidents, is 7·3 per million vehicle kilometres, as compared with a rate of thirty-five accidents per million vehicle kilometres (measured before completion of the new route) on the road which it supersedes. It has also been pointed out that the ease of travel which the road permits between the two cities has caused an "economic tension," that is to say, an increase in activities such as rail traffic and telephone communication between the two cities.

Construction of the motorway from Amsterdam to Utrecht was started before the war and was suspended during hostilities. Work was started again in 1950, and had to be almost stopped a second time after the 1953 floods, because of the call for floating plant and civil engineering manpower and resources. It has been built to the design of the State Authority, the Rijkswaterstaat, whose engineers supervised its construction. The bridge over the Amstel canal was, however, designed by the chief engineer of the city of Amsterdam. This bridge—a prestressed concrete structure—is shown in Fig. 36. A typical bridge overpass is shown in Fig. 38, and an early stage in construction, illustrating the original excavation, is shown in Fig. 37.

THE VELSEN TUNNEL

A combined road and rail tunnel is at present under construction in the Netherlands to give a crossing beneath the North Sea canal—the ship canal which runs from Amsterdam to the North Sea—at Velsen, near Ijmuiden, at the seaward end of the canal. These tunnelling works comprise one of the major civil engineering developments now in progress in the Netherlands. The road tunnel will have dual carriageways in separate chambers, each 7m wide, and will be 1644m long, including the approaches (the actual tunnel will be 768m long), with a powerful ventilation plant on each side of the canal. The railway tunnel will be for two lines, and will be 3224m long, with its approaches, of which 2032m will comprise the tunnel itself. No forced ventilation will be necessary in the railway tunnel, which will be for electric working. Both tunnels have been built to allow future deepening of the North Sea canal to −15·5m, while leaving 0·8m of cover over them.

At the tunnel site, the geological formations consist mainly of fine sand and silt. However, at a level of −16m N.A.P. a stratum of clay, about 1m thick, is found, with a stratum of peat below it. This clay layer

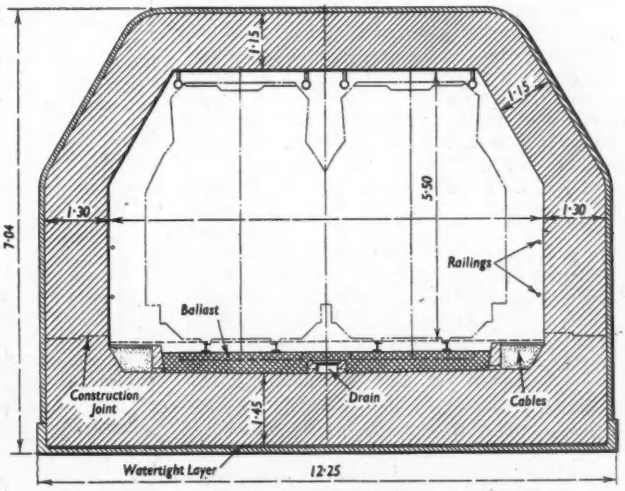


Fig. 40—Cross section of double-track railway tunnel of the Velsen tunnel project

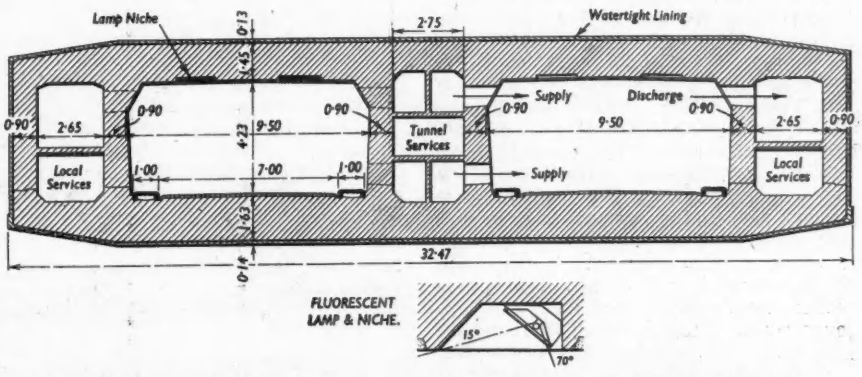


Fig. 39—Cross section of dual carriageway road tunnel forming part of the Velsen tunnel project

exercised a considerable influence on the work. The ground water above the clay is brackish, due to the influence of the canal, but below the clay it is fresh. This source of fresh water is used for the water supply of neighbouring areas, including the city of Amsterdam. It was therefore essential that the fresh water should not become contaminated by the salt water above the clay, as a result of the tunnelling works. One method of construction—that of sinking prefabricated tunnel elements into a trench dug in the canal bottom—was thus precluded, for if it had been used the clay " seal " would have been broken. Of the two remaining possible methods of construction—by driving with a shield or by cut and cover construction—the latter proved better, as will be apparent from the ensuing description. The deciding factors in the choice included the possibility of building both road and rail tunnels in the same excavation, and the method of phasing the canal widening and the tunnel construction. In fact, the tunnel construction as it is now being carried out is a very fine example of the planning of a constructional work.

The drawings, Figs. 39–41, show cross sections through the road and rail tunnels, and a typical cross section through the excavation for the tunnels. The special work at the canal crossing is described further on. In the first stage of dewatering and excavation well-points were installed at the points *A* (Fig. 41) to lower the water table in their immediate vicinity to −8m N.A.P. It was not possible to lower this upper section right down to the clay layer in a single stage of well points, and in any case such an extensive lowering would have had bad effects on surrounding agriculture. Steel sheet piling was therefore driven to penetrate into the clay, just inside the line of the well points, as the cross section shows, to seal off the ground water between −8m N.A.P. and the top of the clay. In the next stage submersible pumps were placed in the wells *B* so as to reduce the hydrostatic pressure of the fresh water underneath the clay stratum until it was safe to uncover the clay in the excavation without fear of " blows " of water breaking through it. A further stage of wells *C* was then constructed from the excavated level of −16m down to −39·5m. The submersible pumps were then moved to the wells *C*, where the final stage of dewatering was completed, enabling excavation to be carried out in the dry to the lines shown in the cross section. On completion of the work the clay layer is being carefully restored.

The tunnels themselves are of substantial reinforced concrete construction. A central concrete plant with weigh batching equipment and two 1 cubic metre mixers is installed at the site on the southern side of the canal, where most of the work up to now has been done. Four concrete pumps are used to transport the concrete to the length under construction. As would be expected, the bottom section of each tunnel is cast first, and travelling steel shutters are used throughout the work. The upper sections are each cast in a single operation. The largest concrete pour is in the construction of an 18m length of the upper section of the road tunnel, for which about 2000 cubic metres of concrete are necessary, and work is continued for twenty-four hours to complete it. The programme of work envisages these large pours at about monthly intervals. A deep reinforced concrete beam is formed in the bottom section of each tunnel, where the longitudinal joints occur. Careful sealing all round the new work is effected with a bituminous sheet material, which, in its turn, is protected by a concrete layer. The specified seven-day strength of the concrete of the tunnel is 300 kg per square centimetre.

The structural shape of the dual road tunnel was fixed largely by the requirements for the carriageways and ventilation ducts, as Fig. 39 indicates. The resulting "skeleton" was analysed statically and tested by photo-

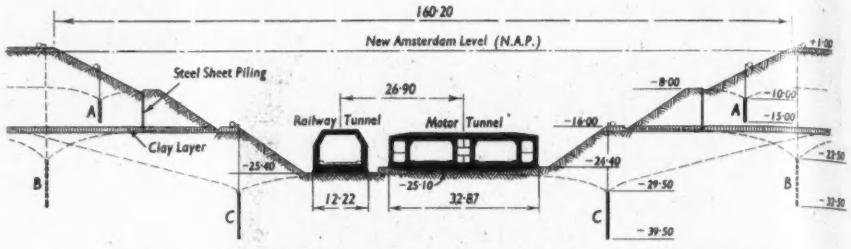
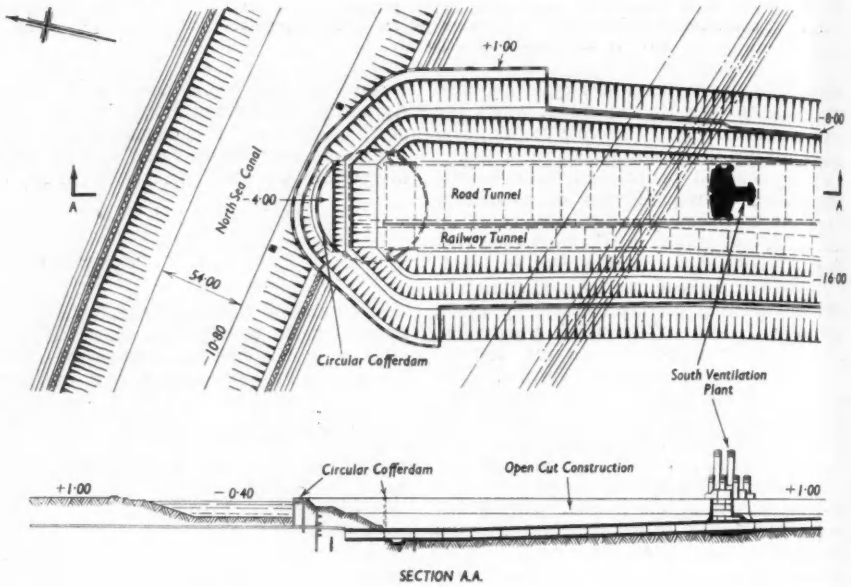


Fig. 41—Typical cross section of the open-cut construction of the Velsen tunnels showing stages in ground water lowering



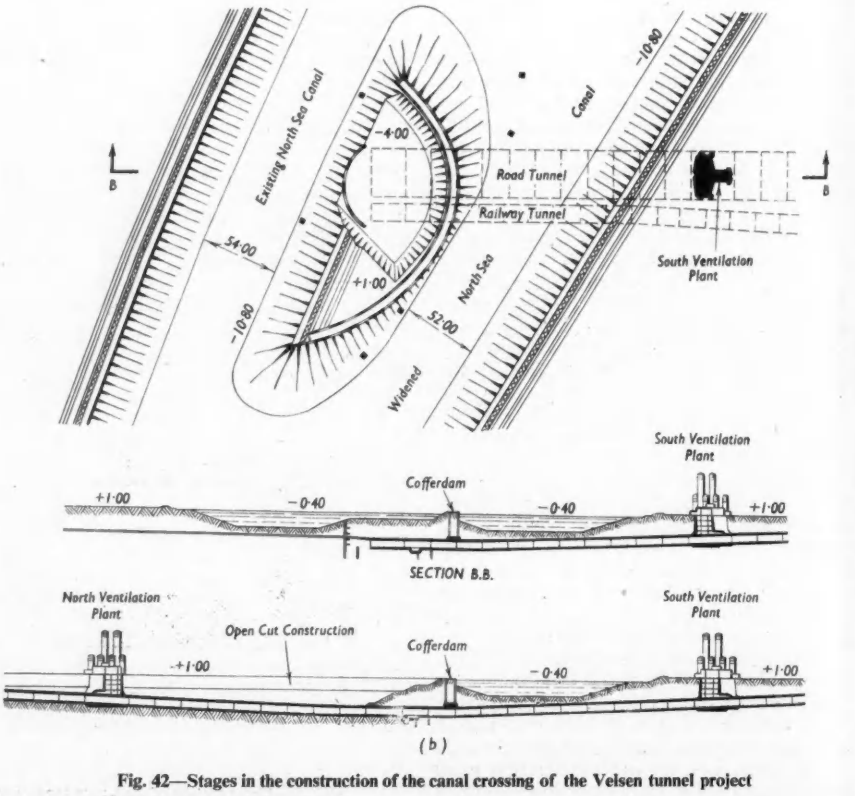


Fig. 42—Stages in the construction of the canal crossing of the Velsen tunnel project

elastic methods, which indicated that it was satisfactory from the structural standpoint.

The Canal Crossing

The stages in the construction of the canal crossing are illustrated in Fig. 42. The first stage (Fig. 42*a*) comprised the construction of a gravity cofferdam, formed of two rows of steel sheet piling braced together, filled between with sand and completed by more filling on the inner side, as shown in the cross section. This cofferdam was built out into the canal as far as navigation permitted. A circular cofferdam was then built just behind the shelter of the gravity cofferdam. The circular cofferdam was 63m in diameter and was formed by driving a very heavy section of steel sheet piling, the piles being 27·5m in length, and bracing it, as excavation proceeded, by heavy reinforced concrete rings. There were five rings in the completed cofferdam. A short length of the dual tunnel was constructed inside the circular cofferdam. When it was complete the cofferdam was partly filled to the slopes shown in the cross section of Fig. 42 (*a*), i.e. to the original ground line on the canal side, sloping down to leave the landward side of the permanent tunnel section still exposed. With the extra support given by this filling the circular wall of steel piling was broken on the landward side, to link with the open excavation, and complete the tunnel on the west side of the canal. This stage of the work has now been reached, and the short length of tunnel built in the cofferdam has been linked with the normal open cut length.

We have already indicated that the canal crossing is to be linked with a scheme for widening the canal. The construction time required for the stages of the canal crossing has, in fact, governed the rate of progress of the work, for it is essential that the canal is kept open to shipping at all times. In the second stage a curved cofferdam will be built over the completed part of the tunnel and cutting off a certain length of the canal bank, as shown in Fig. 42 (*b*). With this cofferdam in position a new canal will be dredged, of about the same width as the old canal, over the completed part of the tunnel. Then, further cofferdams—of the same "gravity" design—will be built across the old canal channel, enclosing a section of the old canal along the line of the tunnelling works which can then be dewatered, and the tunnel completed, as shown in the two lower cross sections of Fig. 42. Finally, the cofferdams will be removed and the old and new canal channels joined to form the new widened canal. Extensive dewatering, similar to that in the normal open-cut work, will be necessary throughout all these stages of the work, and the impermeable clay stratum will everywhere be restored. The open-cut works on the north side of the canal, where work has recently been started, will be very similar to those already described.

An idea of the extent of these works can perhaps be given by quoting some of the quantities involved. Excavation for the whole of the work will total about 2,500,000 cubic metres, and the concrete required will total about 340,000 cubic metres. The length of canal dredged out in the second stage of the crossing will require the removal of 1,500,000 cubic metres of material, in addition to the figure given above for excavation.

Design of Road Tunnel

The double-line railway tunnel did not present any unusual difficulties in the layout of the services of the completed tunnel, and forced ventilation was not considered necessary, although a shaft for natural ventilation is to be provided on each side of the canal. By contrast, the road tunnel has several novel ideas incorporated in its design, to solve problems of ventilation, lighting, noise, and traffic movement.

A cross section through one of the ventilation towers is shown in Fig. 43, from which the general layout will be clear. Air is pumped down the central ducts built between the two carriageways of the road tunnel and is discharged through ducts at each side (Fig. 39), thus giving a transverse ventilation. This

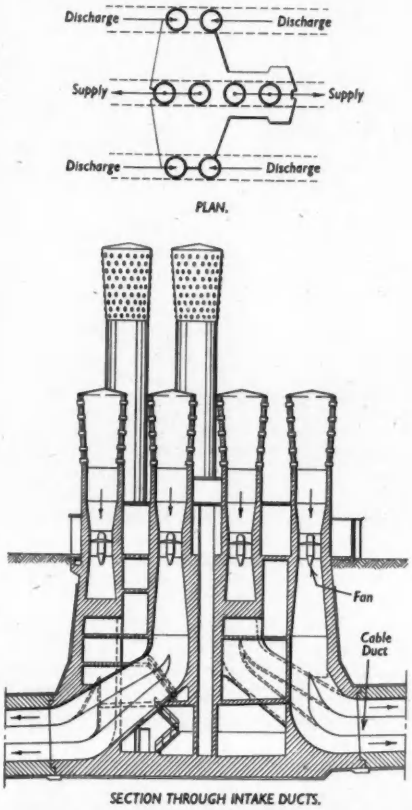


Fig. 43—Cross section of the south ventilation plant of the road tunnel of the Velsen tunnel project

arrangement keeps the construction height to a minimum—an advantage with open-cut work—and permits the spent air to be removed on the right-hand side of the tunnel, where the concentraton of exhaust gases is highest. The two tunnels have separate ventilation systems; hence, the two supply ducts in the centre.

The road tunnel is to be illuminated with fluorescent tubes, fitted in pairs in recesses provided across each tunnel, at 4·5m intervals. The direction of the lighting—i.e. in the direction of travel of the cars—is shown in Fig. 39 in the detail. This form of lighting was decided upon after tests with a 1/5 scale model, during the course of which the spacing of the lighting recesses was determined, and it was found that more uniform lighting of the carriageway was achieved with a dark roof than with a white one. This finding was considered advantageous, for it eliminated the necessity of washing the roof, and made possible the provision of a sound-absorbing lining. The walls of the tunnel have therefore been given a slight outward batter, so that noise will be directed upwards and absorbed at the roof. It is expected that the tunnel will be about as noisy as an average city street.

The difficult transition from the artificial light of the tunnel to the full light of the open road has been solved in a novel manner at Velsen. The road approaches the covered section of the tunnel between retaining walls, the height of which is greater for some distance than the clearance (i.e. 4·2m) required over the carriageways. A grid of reinforced concrete beams is therefore to be constructed across the top of the open roadway, over a length of about 130m at each tunnel entry and exit. This grid serves to strut the upper parts of the retaining walls, and also to prevent direct sunlight from penetrating on to the roadway.

The north-south direction of the tunnel is unfavourable from the point of view of lighting, but apparently a satisfactory solution has been achieved with this grid of reinforced concrete beams. The dimensions of the grid were determined from a one-twentieth scale model. Each reinforced concrete unit of the grid is inclined at 60 deg. to the line of the roadway, and is about 3m in depth and about 1ft in width. They are to be spaced about 2m apart, giving a closely spaced grid with openings of about 2m by 1m in size, measured across and along the axis of the roadway, respectively.

The layout inside the tunnel includes a footpath 1·15m in width, and of such a height that it is possible to open a car door, when the car is drawn up to the kerb. It is pointed out by the designers that the safety margins which a driver automatically observes when driving close to a kerb or a wall will in this case overlap, and the sensation of being closed in by the tunnel side wall, will be largely removed. Furthermore, the fluorescent light fittings will be positioned so that their centre lines will be just outside the centre lines of the traffic lanes. It is expected that drivers will adjust their courses to the lights, thus keeping to the extreme right in the "nearside" lane, and to the extreme left when overtaking.

The Velsen tunnel was designed by the Directie Sluizen en Stuwen (locks and dams directorate) of the Rijkswaterstaat, which body is also responsible for supervising the construction of the tunnel. The contractor was N.V. Amsterdamsche Ballast Maatschappij, Amsterdam, the asphaltic work being done by Key en Kramer Asphalt Ruberoid N.V., Maassluis, and the drainage works by C.V.H.J. Tjaden and Zn, Haarlem. Specialist advice was given by the following bodies:—drainage and ground water levels, State Institute for Drinking Water Supply, The Hague; settlement problems, Laboratory for Soil Mechanics, Delft; tunnel ventilation, Laboratory for Hydro and Aerodynamics, Delft; tunnel lighting, Professor N. A. Halbertsma, The Hague; acoustics, Technical Physics Department T.N.O. and T.H.; architecture, Messrs. Roosenburg, Verhave and Luyt, The Hague; electrotechnical and mechanical problems, R. Kruk, Velsen; paints, Dr. J. Rinse and W. Dorst, Haarlem.

PART III—CORNISH PUMPING ENGINES

DRAINING THE HAARLEM MERE

By W. TREGONING HOOPER

NEXT week the Institution of Mechanical Engineers is holding its summer meeting in Holland. In journeying from Scheveningen to Amsterdam some of the members will travel by road over the flat low-lying ground which, just over 100 years ago, lay at the bottom of a great mere, the Haarlem Mere, whose borders extended close up to Amsterdam itself. The site of the Schiphol airport, which members will visit, lies within the borders of what was once the mere. This article describes the story of the famous Cornish engines erected in Holland in the forties of last century, which drained the mere by 1852 and maintained its drainage for eighty-four years.

A major feature of the history of Holland has been the never-ceasing efforts of the ingenious and persevering Dutch people to prevent encroachment by the sea or to reclaim land already flooded. One of the greatest achievements of Dutch engineers was the drainage of the Haarlem Mere (see Fig. 33, page xvii) in the middle of last century; in this work British engineers played a notable part.

In the sixteenth century the Haarlem Lake had an area of about 6000 acres, and there were also three neighbouring lakes, with an additional water area of 7600 acres. In the course of time "rainfall in excess of evaporation," tempests and inundations merged the four lakes into a great inland sea, which in 1740 covered 42,000 acres; a century later this had increased to 47,000 acres, flooded to an average depth of 13ft, with an estimated water content of 1000 million tons. In 1836 a great hurricane caused widespread damage, flooded the streets of Leyden, and threatened Amsterdam; and in 1839 the Government authorised the reclamation of the whole of the Haarlem Lake and appointed a Commission to prepare a plan and to superintend its execution.

At that time there were said to be 18,000 windmills in Holland, used mainly for land drainage, although steam engines had in some cases been used. As early as 1777 a Newcomen engine with a 52in cylinder had been erected near Rotterdam by M. Van Liender; at a later date Watt sent some of his engines to Holland. "However, a general prejudice existed against the use of steam engines because of the enormous expenditure of fuel, seldom less than 20 lb of coal per horsepower per hour." The Commissioners ascertained that the average coal consumption of steam engines used in land drainage in England and Holland was from 15 lb to 20 lb per i.h.p. per hour, but they were also advised that the large pumping engines used in the Cornish mines were at least sixfold more economical.

This fuel question was important, as consideration had to be given not only to the cost of draining the lake, but also to the standing cost of pumping out the annual inflow of about 54,000,000 tons. In 1840 the Commissioners visited Cornwall "in order to ascertain by actual inspection whether the duty performed by the engines employed in the mines is equal to what is stated in the monthly reports." Tests were carried out on a number of selected large engines with 80in cylinders, and the fuel consumption was proved to be about 2¼ lb of coal per horse-power per hour, or its equivalent in "duty." It was then decided to use steam exclusively for the drainage scheme.

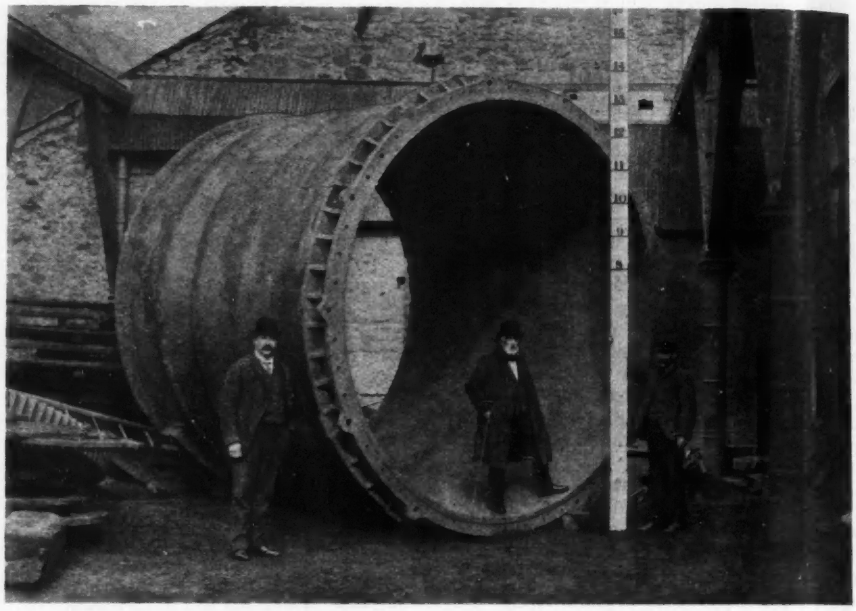


Fig. 45—It is recorded that the Cornish staff of erectors of the Cruiquis engine had a Christmas dinner in 1847 inside the low pressure cylinder

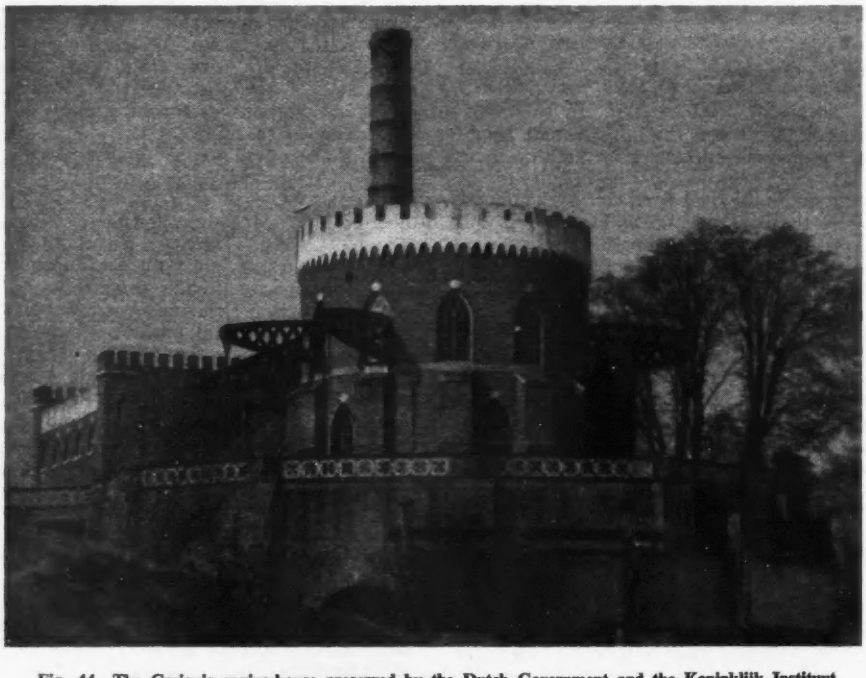


Fig. 44—The Cruiquis engine-house preserved by the Dutch Government and the Koninklijk Instituut van Ingenieurs operates eight pumps 84in diameter

The Dutch engineers or Commissioners then consulted Harvey and Co., of Hayle, who undertook to supply a large engine equal in economy to those tested in the mines. Owing to the low lift of the water to be raised, which averaged only 16ft, the Dutch engineers and their English consulting engineers, Messrs. Gibbs and Dean, of London, were forced to use "bucket lift" pumps; this precluded the use of the ordinary type of Cornish pumping engines to the best advantage, as they used a high degree of expansion, so the use of a modified compound Cornish engine was decided upon, on a plan invented and employed by Mr. James Sims, of Redruth, in 1824 (see Pole's *History of the Cornish Engine*, page 135).

The engine as designed and constructed by Harvey and Co. was described by them as follows:—

"A single-acting compound condensing engine. The high pressure cylinder was 84in in diameter, and turned on the outside, and placed inside the low pressure

cylinder, which was 144 inches in diameter and weighed 24½ tons."

The stroke of the engine was 11ft; the piston-rod of the high-pressure piston was 12in in diameter. The low-pressure piston was annular, and was fitted with four piston-rods, equally spaced. The five piston-rods were connected to a great circular crosshead overhead, which, with the piston-rods and pistons weighed nearly 90 tons. The upper end of the high-pressure piston-rod was continued as a "tail-rod" and passed through a guide bush above the engine; there were also two additional guide rods, which ensured perfect parallel motion. The engine was housed in a circular building with openings for the eleven beams, which were pivoted or balanced on the wall openings. The inner ends of the beams were connected by links with the crosshead, and the outer ends to the eleven pumps of 63in in diameter.

The action of the engine was as follows: the steam distribution was controlled by valve gear identical with that used in the ordinary Cornish engine. The steam was first admitted on the underside of the high-pressure piston, and the dead weight of 90 tons lifted to the top of the stroke, steam being "cut off" at about half stroke. The pumps were now at the bottom of their stroke. The equilibrium valve now opened and steam passed around to the upper sides of the high-pressure and low-pressure pistons; the high pressure being in equilibrium, the underside of the annular low-pressure piston was always in communication with the condenser; the steam pressure on the annular piston plus the weight of the crosshead now caused the pistons to descend on what was really the working stroke, the pumps now lifted the water and discharged it into the drainage canal; the exhaust valve now opened up communication between the top of the cylinder and the condenser, followed by the opening of the steam valve, again admitting steam to the underside of the high-pressure piston, so commencing another cycle.

A Mr. Jebus Bickle, of Harvey and Co., who assisted in the erection of the first or Leegwater engine, in the annual report of the Royal Cornwall Polytechnic Society for 1900, pages 64–69, describes a very ingenious and novel means of controlling the "indoor" or downstroke of the engine. The terminal pressure on the underside of the high-pressure piston at the top of the stroke was insufficient to support the heavy weight of nearly 90 tons, so two hydraulic rams, 9in in diameter, were connected to the crosshead. On the upstroke, water was drawn into the ram cylinders, and retained there by non-return valves. The rams thus partially supported the crosshead and its attachments, allowing a pause, which allowed the pumps to be fully charged. The pump valves were connected to the equilibrium arbor, and when the equilibrium valve opened the same movement opened the valves in the hydraulic cylinders and allowed the downstroke of the engine to take place; this mechanism also safeguarded the engine in case there was a loss of load in the pumps due to a failure of a valve or breakage of a rod.

This engine was erected by Mr. William Husband, C.E., of Harvey and Co.; it was delivered in 1844 and commenced to pump on June 7, 1848. On trial it was found to be capable of pumping 243 million gallons per day of twenty-four hours on a consumption of 2½ lb of coal per horsepower per hour, or a duty of about 90,000,000 ft-lb. per bushel of coal (94 lb). The boiler pressure was 60 lb (absolute) per square inch; the engine worked four double strokes per minute, and developed between 400 h.p. and 500 h.p., about equal to an ordinary 90in Cornish pumping engine. So successful was this engine that two more were ordered from Hayle and Perran Foundries, in Cornwall; they differed only from the Leegwater engine in being fitted with eight pumps of 84in in diameter instead of eleven of 63in. By the middle of 1852 the whole area was completely drained; the enterprise had cost the Dutch Government £1,250,000 sterling, but the reclaimed land sold for about £750,000. This completed what at that time was the most gigantic scheme of land drainage ever attempted, and by the largest pumping engines in the world.

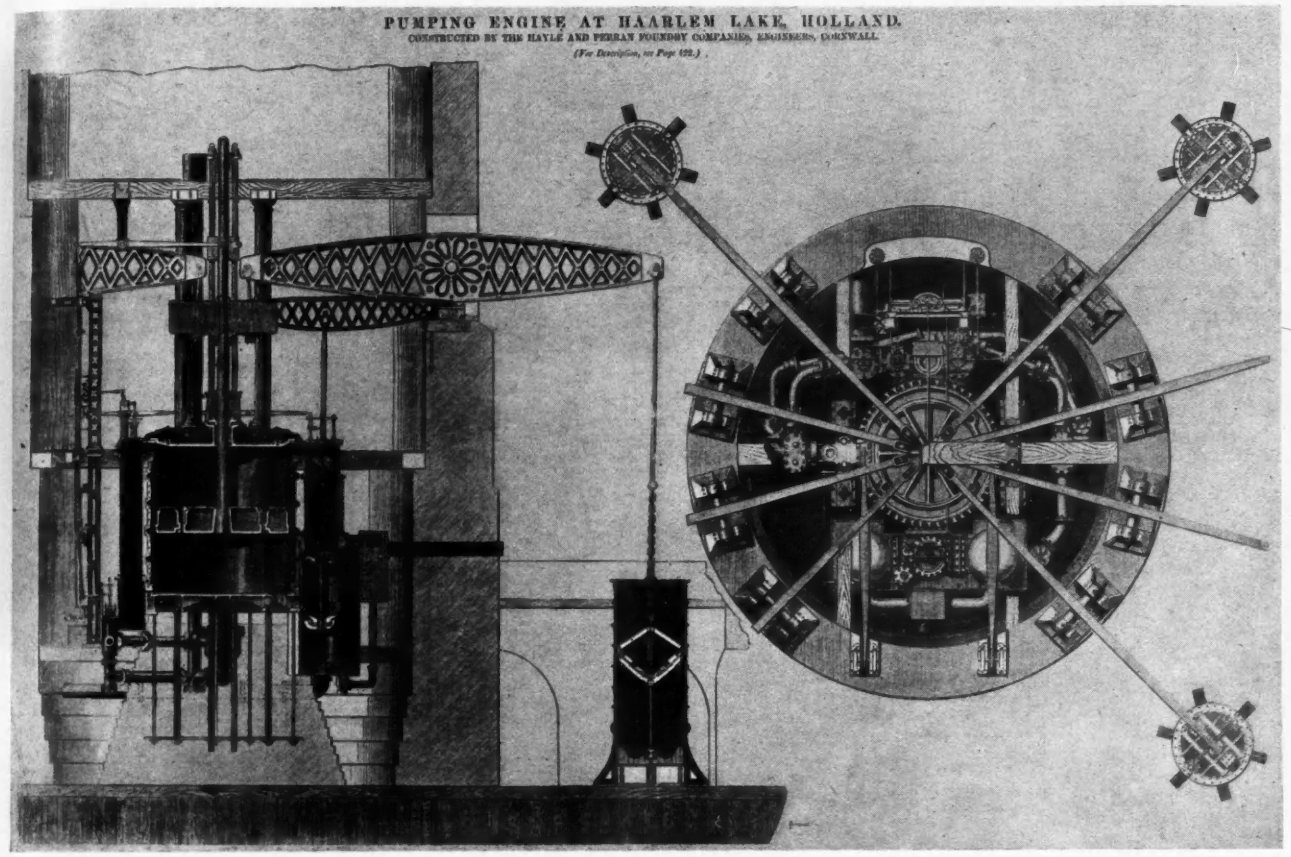


Fig. 46—The Leegwater pumping engine operated eleven 63in pumps. The Cruiquis and Van Lynden engines were arranged as shown here to operate eight 84in pumps

These pumping engines worked for eighty-four years and only minor repairs were ever necessary. The Van Lynden engine was again visited by Mr. Bickle in 1893; this Perran built engine was still working as well as ever, and the engine driver who had helped to erect it said, "it has never cost a guilder for repairs or renewals." The third engine at Cruiquis, a Harvey-built engine, has been preserved by the Dutch Government; it was the last to be erected and was ready for service in 1849. It was erected by Mr. Matthew Loam, a brother to the celebrated Cornish engineer, Michael Loam.

The first and third illustrations, the latter from an engraving in *Engineering*, April 26, 1867, show the Cruiquis engine house and the arrangement of the Van Lynden and Cruiquis engines. The second illustration shows the casting for one of the low-pressure cylinders.

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